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ECONOMIC ANALYSIS OF EFFLUENT GUIDELINES FOR THE INORGANIC CHEMICALS INDUSTRY

ARTHUR D. LITTLE, INCORPORATED

PREPARED FOR
ENVIRONMENTAL PROTECTION AGENCY

APRIL 1974

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An analysis of the economic impact of proposed water effluent guidelines upon 24 inorganic chemicals was performed based on water treatment cost data supplied by the EPA. The inorganic chemicals included aluminum chloride, aluminum sulfate, chlorine and caustic soda, hydrochloric acid, hydrofluoric acid, hydrogen peroxide, lime, nitric acid, sulfuric acid, calcium carbide, sodium sulfate, titanium dioxide (chloride process), titanium dioxide (sulfate process), sodium bichromate, potassium bichromate, sodium bicarbonate, solar salt, evaporated salt, sodium silicate, sodium metal, sodium sulfite, calcium chloride, synthetic soda ash, and potassium sulfate. A methodology was developed to systematically judge the broader economic effects on these chemicals, resulting from application of water effluent control, first by assessing the likelihood that treatment costs would be defrayed through price increases, and secondly, if price increases were not likely, the likelihood that plant shutdowns would occur. Based on this approach and using the treatment costs supplied, it was concluded that plant shutdowns would occur for mercury cell chlorine/caustic, lime, sludge sulfuric acid, sulfate process titanium dioxide and sodium bichromate if either best practicable technology or best available technology standards were imposed on these industries.

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ECONOMIC ANALYSIS OF EFFLUENT GUIDELINES
FOR
THE INORGANIC CHEMICALS INDUSTRY

April 1974

Contract No. 68-01-1541

Office of Planning and Evaluation
Environmental Protection Agency
Washington, D.C. 20460

PREFACE

The attached document is a contractor's study prepared with the supervision and review of the Office of Planning and Evaluation of the U.S. Environmental Protection Agency (EPA). Its purpose is to provide a basis for evaluating the potential economic impact of effluent limitations guidelines and standards of performance established by EPA pursuant to sections 304(b) and 306 of the Federal Water Pollution Control Act.

The study supplements an EPA technical "Development Document" issued in conjunction with the promulgation of guidelines and standards for point sources within this industry category. The Development Document surveys existing and potential waste treatment and control methods and technologies within this category and presents the investment and operating costs associated with various control technologies. This study supplements that analysis by estimating the broader economic effects (including product price increases, continued viability of affected plants, industry growth and foreign trade) of the required application of certain of these control technologies.

This study has been submitted in fulfillment of Contract No. 68-01-1541, Task No. 30 by Arthur D. Little, Inc. Work was completed as of April 1974. The study is based primarily upon an earlier study, also prepared by Arthur D. Little, Inc., entitled "Economic Analysis of Proposed Effluent Guidelines for Inorganic Chemicals, Alkali and Chlorine Industries." The earlier report was circulated in conjunction with the publication in the Federal Register of a notice of proposed rulemaking under sections 304(b) and 306 for the subject point source category. The analysis contained in the original study has been revised based upon information received during the period of time between publication of the notice of proposed rulemaking and the promulgation of the final regulation. Because of the constraints of time, the control and treatment costs analyzed in this study may not in all instances be identical to those associated with the requirements of the promulgated regulation. However, those differences, when they exist, are minor insofar as the final conclusions of the study are concerned.

This report represents the conclusions of the contractors. It has been reviewed by the Office of Planning and Evaluation and approved for publication. Approval does not signify that the contents necessarily reflect the views of the Environmental Protection Agency. The study has been considered, together with the Development Document, information received in the form of public comments on the proposed regulation, and other materials in the establishment of final effluent limitations guidelines and standards of performance.

TABLE OF CONTENTS

	Page
List of Tables	ix
List of Figures	xiii
I. SUMMARY	1
A. INTRODUCTION	1
B. IMPACT ANALYSIS METHODOLOGY	2
C. INITIAL AND MAJOR STUDY PRODUCTS	5
D. ADDITIONAL STUDY PRODUCTS	11
II. INDUSTRY CHARACTERIZATION--MAJOR STUDY PRODUCTS	26
A. CALCIUM CARBIDE	26
B. SODIUM SULFATE	39
C. TITANIUM DIOXIDE	57
D. SODIUM CHROMATE AND BICHROMATE	79
E. POTASSIUM CHROMATE AND BICHROMATE	93
III. IMPACT ANALYSIS--INITIAL STUDY PRODUCTS	95
A. ALUMINUM CHLORIDE	95
B. ALUMINUM SULFATE	96
C. CHLORINE AND CAUSTIC SODA	97
D. HYDROCHLORIC ACID	99
E. HYDROFLUORIC ACID	100
F. HYDROGEN PEROXIDE	101
G. LIME	102
H. NITRIC ACID	103
I. SULFURIC ACID	104

Preceding page blank

TABLE OF CONTENTS (Continued)

Page

IV. IMPACT ANALYSIS--MAJOR STUDY PRODUCTS 107

A. CALCIUM CARBIDE 107

B. SODIUM SULFATE 108

C. TITANIUM DIOXIDE 109

D. SODIUM CHROMATE AND BICHROMATE 114

V. IMPACT ANALYSIS--ADDITIONAL PRODUCTS 116

A. SODIUM BICARBONATE 116

B. SOLAR SALT 119

C. EVAPORATED SALT 121

D. SODIUM SILICATE 123

E. SODIUM METAL 126

F. SODIUM SULFITE 130

G. CALCIUM CHLORIDE 133

H. SYNTHETIC SODA ASH 135

I. POTASSIUM SULFATE 138

Preceding page blank

LIST OF TABLES

Table No.		Page
1	WATER TREATMENT COSTS BY LEVELS OF CONTROL	6
2	MANUFACTURING COSTS AND PLANT ECONOMICS	7
3	IMPACT ANALYSIS MATRIX	12
4	CALCIUM CARBIDE PRODUCTION, IMPORT/EXPORT, AND APPARENT CONSUMPTION	27
5	TOTAL MARKET VALUE OF CALCIUM CARBIDE PRODUCTION	28
6	USE PATTERN OF CALCIUM CARBIDE BY APPLICATION	30
7	CAPTIVE VS. COMMERCIAL CONSUMPTION OF CALCIUM CARBIDE	32
8	CALCIUM CARBIDE PRODUCERS--LOCATION AND CAPACITY	34
9	ESTIMATED COST OF MANUFACTURING CALCIUM CARBIDE	36
10	CALCIUM CARBIDE PRICES--PUBLISHED VS. ACTUAL	38
11	SODIUM SULFATE PRODUCTION, IMPORT/EXPORT, AND APPARENT CONSUMPTION	40
12	USE PATTERN OF SODIUM SULFATE BY APPLICATION	42
13	GEOGRAPHIC USE PATTERN OF SODIUM SULFATE	44
14	CAPTIVE VS. COMMERCIAL CONSUMPTION OF SODIUM SULFATE	46
15	PRODUCTION OF SODIUM SULFATE BY PROCESS	47
16	SODIUM SULFATE PRODUCTS--LOCATION AND CAPACITY	53
17	SODIUM SULFATE PRICES--PUBLISHED VS. ACTUAL	56
18	$T1O_2$ APPARENT CONSUMPTION AND INDUSTRY SHIPMENTS	59
19	$T1O_2$ MARKET CONSUMPTION	60
20	$T1O_2$ CAPTIVE CONSUMPTION	63

Preceding page blank

LIST OF TABLES (Continued)

Table No.		Page
21	TiO_2 MANUFACTURING LOCATIONS AND CAPACITIES	67
22	TiO_2 MANUFACTURING ECONOMICS--SULFATE PROCESS	68
23	TiO_2 PIGMENT PROFITABILITY--SULFATE PROCESS	70
24	TiO_2 MANUFACTURING ECONOMICS--CHLORIDE PROCESS	72
25	TiO_2 PIGMENT PROFITABILITY--CHLORIDE PROCESS	74
26	TiO_2 INDUSTRY PLANT CAPACITY UTILIZATION	77
27	TiO_2 COMMERCIAL SHIPMENT VALUES	78
28	APPARENT U.S. CONSUMPTION OF SODIUM CHROMATE AND BICHROMATE	81
29	ESTIMATED 1971 USE PATTERN FOR SODIUM CHROMATE AND BICHROMATE	82
30	PRODUCTION OF CHROMIUM PIGMENTS AND CONSUMPTION OF SODIUM BICHROMATE EQUIVALENT, 1971	83
31	SHIPMENTS OF SODIUM CHROMATE AND BICHROMATE	86
32	ESTIMATED MANUFACTURING COST, SODIUM BICHROMATE	88
33	PRODUCERS OF SODIUM BICHROMATE	90
34	ACTUAL VS. LIST PRICES FOR SODIUM BICHROMATE	92
35	ESTIMATED MANUFACTURING COST, POTASSIUM BICHROMATE	94

Preceding page blank

LIST OF FIGURES

Figure No.		Page
1	INCREMENTAL WATER TREATMENT COSTS FOR BEST AVAILABLE TECHNOLOGY VERSUS SELLING PRICE AND PROFIT MARGIN	8
2	INCREMENTAL WATER TREATMENT COSTS FOR BEST PRACTICABLE TECHNOLOGY VERSUS SELLING PRICE AND PROFIT MARGIN	10
3	SCHEMATIC FLOW DIAGRAM--PRODUCTION OF CALCIUM CARBIDE	33
4	RECOVERY OF SODIUM SULFATE FROM NATURAL BRINES	49
5	PRODUCTION OF SODIUM SULFATE IN VISCOSE RAYON PROCESS	50
6	PRODUCTION OF SODIUM SULFATE IN THE MANNHEIM PROCESS	51
7	TiO_2 PIGMENT MANUFACTURING PROCESSES	65

I. SUMMARY

A. INTRODUCTION

The following report is submitted in compliance with Task Order No. 30 to BOA No. 68-01-1541, "Economic Impact of 1972 Federal Water Pollution Control Amendments on the Inorganic Chemical Industry." As outlined in our proposals, this report deals with 24 inorganic chemicals, including the nine discussed in the initial study;[1]

Aluminum Chloride
Aluminum Sulfate
Chlorine and Caustic Soda
Hydrochloric Acid
Hydrofluoric Acid
Hydrogen Peroxide
Lime
Nitric Acid
Sulfuric Acid

as well as the six inorganic chemicals studied in depth;

Calcium Carbide
Sodium Sulfate
Titanium Dioxide (Chloride)
Titanium Dioxide (Sulfate)
Sodium Chromate and Bichromate
Potassium Bichromate

and the nine additional products briefly reviewed in a subsequent analysis;

Sodium Bicarbonate
Solar Salt
Evaporated Salt
Sodium Silicate
Sodium Metal
Sodium Sulfite
Calcium Chloride
Synthetic Soda Ash and
Potassium Sulfate.

---

[1] "Initial Analysis of the Economic Impact of Water Pollution Control Costs Upon Ten Inorganic Chemicals," report to Environmental Protection Agency by Booz, Allen Public Administration Services, Inc., January 5, 1973.

The objective of this study was to analyze the economic impact of the costs of water pollution abatement requirements for the specified products, using the data for the nine initial study products contained in the initial impact study, new water treatment cost data provided by EPA and the industry information developed for the major study products and the additional study products by the contractor.

B. IMPACT ANALYSIS METHODOLOGY

In order to assess the impact of water treatment costs on the inorganic chemicals covered in this report, we have developed an analytical framework to arrive at the impact judgment. In addition to providing us with a systematic method to weigh each of the factors affecting the impact judgment, the methodology also provides a format by which the basis for our conclusions are clearly presented.

The basic premise behind the methodology is that a producer faced with new investment in water treatment facilities could (1) continue to operate by (a) passing on the additional costs through price increases, or (b) absorbing the costs (thereby reducing profits); or (2) shut his plant down. This premise, of course, reduces the impact of increased costs due to water treatment to the simplest terms. In the real world, the result of higher costs most probably would be some combination of these alternatives, e.g., a price hike by the most efficient producer sufficient to recover part of his costs (but not enough to cover most of the costs of the marginal producer), reduced profit margins for the most efficient producer partially offset by an increased market share resulting from plant shutdowns by the marginal producer(s).

The approach we have taken in assessing the impact on each of the inorganic chemicals is to first examine the likelihood that the higher costs imposed on the industry by virtue of new water effluent guidelines will be defrayed, wholly or in part, by higher product prices. If the conclusion is that treatment costs cannot be passed on through price increases, the second part of the impact analysis is to examine the likelihood that some plants in the industry would be forced to shut down, taking into account both economic and noneconomic factors.

1. Price Increase Constraints

The treatment costs per ton before taxes indicate the magnitude of the unit price increase necessary to fully recover all treatment costs (i.e., repay the investment and cover operating costs). The larger the ratio of before-tax unit treatment cost to actual unit selling price, the more difficult it will be to fully recover treatment costs, all things being equal. As indicated, the first question we have addressed is whether conditions in the specific competitive situation would permit price increases. In general, the products' price history and the nature of those prices--whether firm or widely dispersed and discounted--provide a clue as to the possibility of price increases. More specifically, however, the following factors are those that we have used in arriving at the judgment as to whether price increases are feasible. Except in unusual circumstances, no one factor would be overriding. Rather, the judgment is based on a combination of factors.

Substitute Products (or Processes)--If substitute products exist, price increases to cover the (full) costs of water treatment would be difficult.

Capacity Utilization--If capacity utilization for the industry is low, price increases to cover the (full) costs of treatment would be difficult.

Captive Usage--If there is negligible captive use, price increases to cover the (full) costs of water treatment would be difficult.

Demand Growth--Price increases are more difficult to achieve in a static or declining market than in a growing market.

Foreign Competition--If the market can be served by foreign competitors (particularly if the foreign producers are not faced with added water pollution abatement costs), price increases are less likely.

Abatement Cost Differences--If some plants in the industry will incur substantially higher water pollution abatement expenditures than other plants, they will be less able to pass on the added costs as price increases.

Price Elasticity of Demand--For some products, substantial water pollution abatement costs, if passed on as price increases, could result in reduced demand for the product.

Basis for Competition--If the basis for competition in the industry is primarily price as opposed to service or technology, cost increases will be more difficult to pass on, particularly if there is a significant difference between unit treatment costs between large producers and small producers.

Market Share Distribution--If the market share distribution is fragmented (rather than concentrated, in which case there often is a dominant price leader), price increases are less likely, particularly if treatment costs do not affect all producers fairly equally.

Number of Producers--If the market is served by many producers (increasing the likelihood of manufacturing cost differences, abatement cost differences, etc.), a condition exists constraining price increases.

Although not explicitly listed in the generic model, we have been alert to other factors which might prevail for individual products. For example, the economic importance of a product in the manufacturing costs of derivative products might act as a constraint on price increases.

In assessing the possibiliy of water treatment costs being passed on as titanium dioxide price increases, for instance, we took into account the impact on titanium dioxide demand of the resultant increase in the cost of paint.

2. Plant Shutdown Factors

If treatment costs cannot be passed on as price increases, the simplistic model says that the producer either absorbs them or shuts down his plant. The shutdown decision will involve both economic and strategic (i.e., noneconomic) considerations as follows.

Profitability--The after-tax cost per ton of water treatment compared with unit after-tax net income measures the producer's ability or willingness to absorb the added cost.

Cash Flow--Plants will continue to operate temporarily at essentially zero profitability (if necessary) if the plant is producing a positive cash flow (and has a competitive process and is in a stable or growing market).

Ratio of Investment in Treatment Facilities to Net Fixed Investment--If the new investment in water treatment facilities bulks large in comparison with existing plant investment (and other factors are marginal), a shutdown decision may be in order. In some instances, the availability (and cost) of capital to the producer may influence the shutdown decision.

Integration--The degree of backward or forward integration is a factor in the shutdown decision. A producer (or industry) with a significant raw material position or one using the product for downstream manufacture is less likely to curtail production than a non-integrated producer (or industry).

Chemical Complex--An isolated plant would be unable to take advantage of common treatment facilities.

Other Environmental Problems--If a plant has already commited funds for air pollution, it will be more likely to commit the additional funds necessary for water pollution. Alternately, if a company faces both water and air pollution abatement (and/or unusual OSHA) costs, the magnitude of the environmental costs taken together may prompt plant closing whereas any one taken alone would not.

Emotional Commitment--The emotional commitment of the company to that particular product (taking into account protection of competitive position, prestige, the importance of the product in the company's long-range strategy, etc.) may be a factor in the shutdown decision.

Ownership--Other things being equal (and negative), multi-industry companies are more likely to shut down marginal plants than less-diversified producers. The premise is that the multi-industry producer has other (and better) investment opportunities than the single product company (particularly a privately-held, family business).

C. INITIAL AND MAJOR STUDY PRODUCTS

1. Water Treatment Costs

All of the water treatment costs for the various levels of effluent control shown in this report were taken from the Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for the Major Inorganic Products prepared for the EPA under contract number 68-01-1513 dated June 1973. The water treatment costs (on a before-tax basis) by product are summarized in Table 1. Base-level practice (B.L.P.) represents water treatment practices which, in the judgment of the Development Document, are followed by most of the industry and exceeded by exemplary plants. Similarly, exemplary plant practice (E.P.P.) reflects the unit cost of water treatment and control practices at the exemplary plant. Proposed best practicable technology (B.P.T.) reflects the Development Document's estimate of the unit water treatment cost for the product in question based upon the best technically and economically feasible treatment and control technology. Finally, proposed best available technology (B.A.T.) reflects the degree of effluent reduction which must be achieved by July 1, 1983. The unit treatment costs used for any particular level of control in the impact analysis is the incremental cost over B.L.P.

2. Manufacturing Costs and Profitability

In the following report the manufacturing costs and profitability data shown in Table 2 for the "Initial Study Products" were taken from the initial study project. Comparable data for the six "Major Study Products" were developed by the Contractor.

3. Conclusions

In Figure 1 we have compared the incremental (over B.L.P.) water treatment costs estimated in the Development Document to achieve B.A.T. effluent standards as a function of product selling price versus treatment costs as a function of unit profit margin for the inorganic chemicals discussed in this study. Three initial study products do not appear on the figure because data for industry profitability were not developed. For the three products (hydrochloric acid, nitric acid, and hydrogen peroxide), however, unit treatment costs are small so that these products would appear in the lower left-hand corner of the figure. One of the major study products, viz. calcium carbide, has also been left off the figure. With a treatment cost of $1.94 per ton versus a selling price of $90 per ton, the cost/price ratio is a nominal 2.2%. However, since industry profit margins are minimal, the treatment cost as a function of unit margins is very high and falls off the scale of the figure.

Titanium dioxide stand out in this figure as the product where the estimated treatment costs represent the highest proportion of both selling price and profit margin. (For both the chloride and sulfate

TABLE 1

WATER TREATMENT COSTS BY LEVELS OF CONTROL
(Dollars Per Ton of Product)

	Base-Level Practice	Exemplary Plant Practice	Best Practicable Technology	Best Available Technology
Initial Study Products				
Aluminum Chloride	0.00	3.77	3.77	3.77
Aluminum Sulfate	0.79	1.72	1.72	1.72
Chlorine				
(Mercury)	2.14	2.14	2.74	3.00
(Diaphragm)	0.04	0.29	0.29	0.56
Hydrochloric Acid	0.25	0.25	0.30	0.30
Hydrofluoric Acid	3.57	4.04	4.89	12.95
Hydrogen Peroxide				
(Organic)	0.20	0.33	1.06	1.06
(Electrolytic)	0.00	0.75	1.14	1.14
Lime				
(Bag)	0.00	0.00	0.00	0.00
(H_2O Scrubber)	0.00	1.28	1.28	1.28
Nitric Acid	0.00	0.22	0.22	0.22
Sulfuric Acid				
(Burning)	0.05	0.10	0.17	0.17
(Regen)	0.25	0.75	0.75	0.75
Major Study Products				
Calcium Carbide	0.00	1.94	1.94	1.94
Sodium Sulfate	0.00	0.00	0.00	0.00
Titanium Dioxide				
(Sulfate)				
[Neutralization]	1.90	10.05	83.57	98.09
[Acid Recovery]	1.69	10.05	35.71	50.48
(Chloride)	2.12	38.61	38.61	66.79
Sodium Chromate and Bichromate	0.26	11.66	16.45	16.45
Potassium Bichromate	0.57	3.52	5.24	5.24
Additional Products				
Sodium Bicarbonate	0.03	0.04	0.04	0.04
Solar Salt	2.34	2.34	2.34	2.34
Evaporated Salt	0.00	0.23	0.44	0.44
Sodium Silicate	0.19	0.60	1.14	1.14
Sodium Metal	0.19	3.07	5.53	5.53
Sodium Sulfite	0.00	3.09	2.98	(1.56)*
Calcium Chloride	0.00	0.19	0.19	0.19
Soda Ash--Synthetic	0.44	(1.17)*	0.44	1.10
Potassium Sulfate	0.10	2.47	2.47	2.47

*Before-tax profit.

Source: Development Document on inorganic chemicals, alkali and chlorine industries prepared for United States Environmental Protection Agency under Contract Number 68-01-1513, June 1973.

TABLE 2

MANUFACTURING COSTS AND PLANT ECONOMICS

	Selling Price	Manufacturing Cost[1]	After Tax Net Income	Depreciable Investment	Sample Plant Capacity
	($/Ton)			$MM	M Tons/Year
Initial Study Products					
Aluminum Chloride	292	226	21	1.2	10
Aluminum Sulfate	42	32	3	1.0	33
Chlorine and Caustic Soda					
Mercury	101[2]	N.A.	4.12	13	66
Diaphragm	101[2]	81	4.33	20	115
Hydrofluoric Acid	370	N.A.	18	5	21
Lime	16	12	1.00	4	165
H_2SO_4					
Burning	20	14	1.20	6	330
Regeneration	22	16	1.20	9	330
Major Study Products					
Calcium Carbide	90	86	0	4	45
Titanium Dioxide--					
Sulfate	540	416	26	15	25
Chloride	570	471	21	21	25
Sodium Bichromate	245	212	18	5	49
Potassium Bichromate	475	403	24	2	5

[1] Excluding GS&A and federal income taxes.

[2] Sales revenue per ECU.

Source: Initial Study Products: "Initial Analysis of the Economic Impact of Water Pollution Control Costs Upon Ten Inorganic Chemicals," final report to Environmental Protection Agency for Booz, Allen Public Administration Services, Inc., January 5, 1973.
Major Study Products: The Contractor.

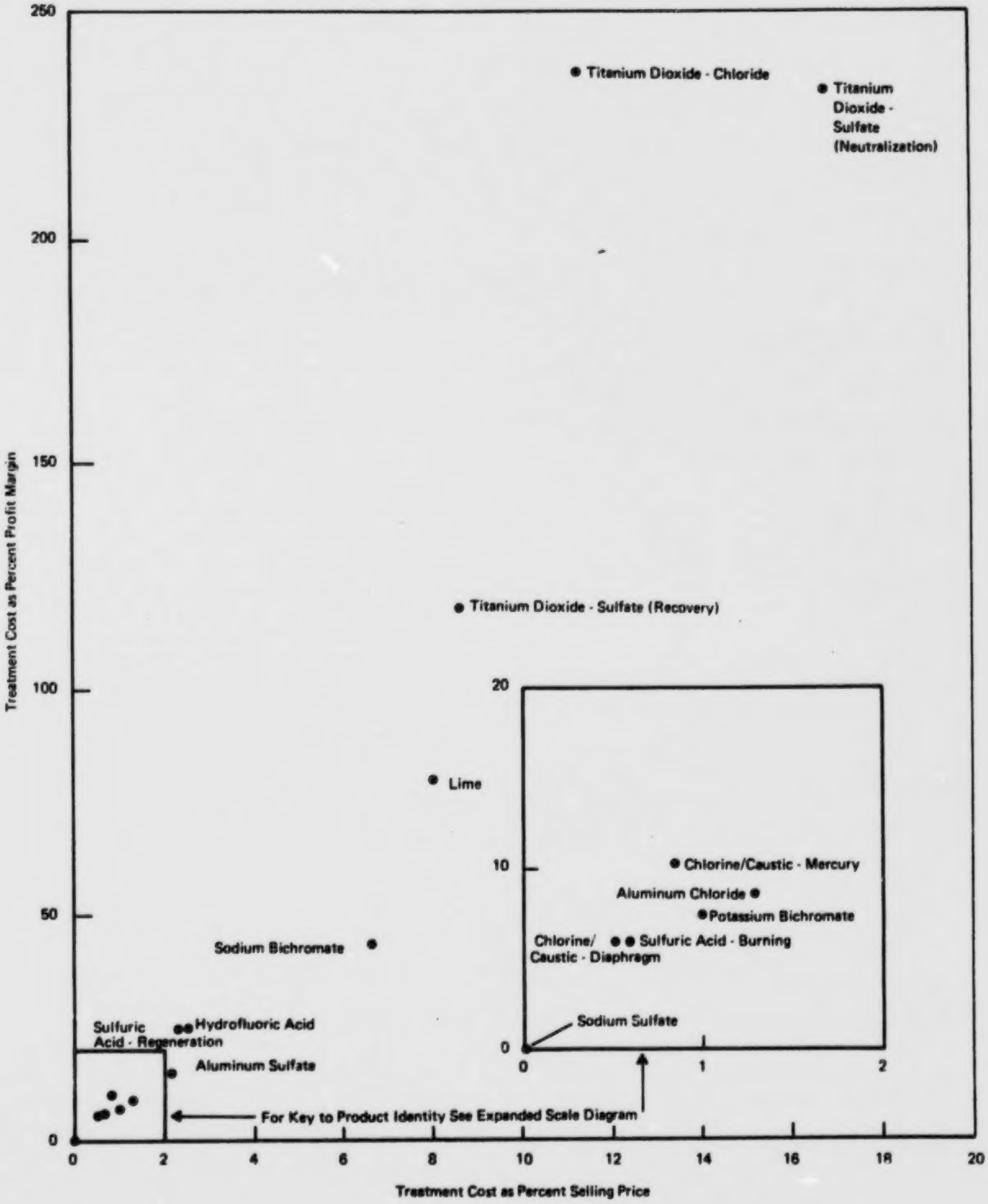

FIGURE 1 **INCREMENTAL WATER TREATMENT COSTS FOR BEST AVAILABLE TECHNOLOGY VERSUS SELLING PRICE AND PROFIT MARGIN**

process, the estimated treatment costs on a unit basis are very nearly 2.5 times current estimated industry profit levels.) Lime and sodium bichromate are at an intermediate level where treatment costs represent 7-8% of selling price and 50-80% of estimated profit margins. A third group of products--hydrofluoric acid, sludge sulfuric acid, and aluminum sulfate--are faced with treatment costs representing 2-3% of selling price and 15-25% of estimated profit margins. A final group of products including aluminum chloride, potassium bichromate, chlorine and caustic soda, and direct burning sulfuric acid, have estimated treatment costs at about 1% of selling price and 5-10% of profits. No water treatment costs were ascribed to sodium sulfate (as chromate by-product).

The same comparison is made in Figure 2 using incremental water treatment costs for B.P.T. In general, the spatial relationships between the identified products is much the same as in Figure 1, with the exception that sulfate process titanium dioxide is at a greater disadvantage with respect to chloride process titanium dioxide.

Although Figures 1 and 2 provide a first approximation of the impact severity on each of the products from additional water treatment costs, we have used the methodology described above to assess the economic impact. The results of this assessment are summarized in Table 3. From this table and based on the treatment costs given in the Development Document we conclude that plant shutdowns as a direct result of increased water treatment costs using B.A.T. are likely for chlorine/caustic soda, lime, sludge sulfuric acid, sulfate process titanium dioxide and sodium bichromate. Although the B.A.T. costs for potassium bichromate could be passed on through a price increase the one significant manufacturing facility could not continue operating if the sodium bichromate plant upon which it depends were shut down. For the other products included in the study the increased water treatment costs will either be passed on as price increases or absorbed by the producers.

The final effluent guidelines, published in the March 12, 1974, Federal Register contain some changes from the originally proposed guidelines. Among others, the B.A.T. standards for mercury cell chlorine/caustic and sulfate process titanium dioxide have been modified to allow higher suspended solids. The aforementioned plant shutdown conclusions are based on the guidelines and estimated treatment costs contained in the original Development Document dated June 1973.

The same shutdown conclusions pertain as well for B.P.T. For three of the five shutdown candidates--viz. lime, sludge sulfuric acid, and sodium bichromate--B.P.T. costs are identical to B.A.T. costs. It should be noted that the regulation as promulgated for B.P.T. standards for sodium bichromate has been relaxed somewhat from the originally proposed regulation. For the remaining two--viz. mercury cell chlorine/caustic and sulfate process titanium dioxide--the costs resulting from B.P.T. were not judged to be significantly different (i.e., lower) than B.A.T. costs to impact the industries less severely.

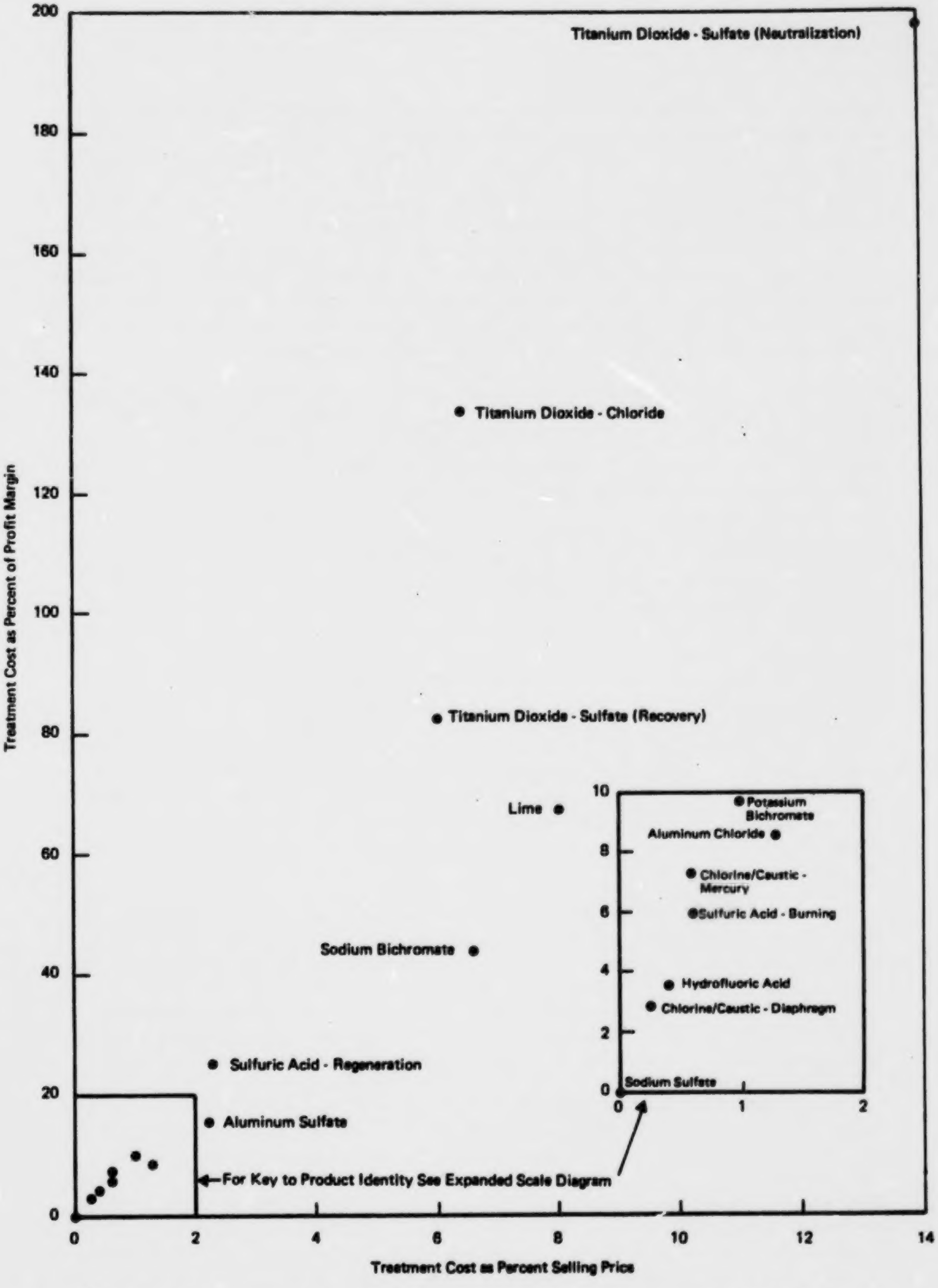

FIGURE 2 INCREMENTAL WATER TREATMENT COSTS FOR BEST PRACTICABLE TECHNOLOGY VERSUS SELLING PRICE AND PROFIT MARGIN

D. ADDITIONAL STUDY PRODUCTS

1. Water Treatment Costs

All of the water treatment costs for the various levels of effluent control shown in this report were taken from the Development Document prepared for the EPA under contract number 68-01-1513 dated June 1973.

The water treatment costs provided by the Development Document and summarized in Table 1 were specific to a particular manufacturing process for each of the products under consideration. In general, this manufacturing process is not the only method for producing the products being considered, or in some cases not even the major method of production. Our judgment of economic impact, however, is necessarily predicated on these costs and we have, therefore, confined our judgment to the economic impact on the producers utilizing the particular process defined by the Development Document. The processes are specified in the individual product studies.

2. Conclusions

The impact analysis matrix (Table 3) also summarizes the relevant price increase and plant shutdown impact considerations for the additional products. For none of the nine additional products do we see plant shutdowns as a direct result of increased water treatment costs. For one of the nine--sodium metal--there may be plant shutdowns as a result of possible reduced demand for alkyl leads in gasoline.

The Development Document indicates that for solar salt there would be no incremental cost for B.P.T. or B.A.T. over E.P.P. and consequently no economic impact. For sodium bicarbonate, evaporated salt, sodium silicate, and calcium shloride, the conclusion is that water treatment costs can be passed on as price increases. For sodium metal, sodium sulfite, and potassium sulfate, the water treatment costs will either be absorbed by the producer or passed on as price increases. Finally, for sodium carbonate the nominal incremental cost for B.A.T. over E.P.P. will be absorbed by the producer. (The original Development Document indicates that there is no incremental cost over E.P.P. for B.P.T. for synthetic soda ash.)

TABLE 3
IMPACT ANALYSIS MATRIX

PRICE INCREASE CONSTRAINTS: Factor	Condition for Constraint	Treatment Level	ALUMINUM CHLORIDE	ALUMINUM SULFATE	CHLORINE & CAUSTIC SODA (Mercury)	CHLORINE & CAUSTIC SODA (Diaphragm)
1972 Production (M Tons)			34	1,124	9,870 (Cl_2);	10,710 (NaOH)
1971 Unit Value ($/Ton)			292	42.50	45.50 (Cl_2);	47.80 (NaOH)
1972 Production Value ($MM)			9.4	47.8	464 (Cl_2);	525 (NaOH)
Number of Plants (Current)			8	100	29**	34**
Ratio of BT* Treatment Cost to Selling Price (%)	High	E.P.P. B.P.T. B.A.T.	1.3 1.3 1.3	2.2 2.2 2.2	0.0 0.6 0.8	0.25 0.25 0.52
Substitute Products	High Occurrence		Low	Low	Low	
Capacity Utilization	Low		65%	ca. 75%	95%	
Captive Usage	Low		Low	<10%	62% (Cl_2);	33% (NaOH)
Demand Growth	Low		Static	3%/Yr	6%/Yr (Cl_2);	5% (NaOH)
Foreign Competition	High		Low	< 1%	Low	
Abatement Cost Differences	Unequal		Equal	Unequal	Unequal	
Price Elasticity of Demand	High		Low	Low	Low to Moderate	
Basis for Competition	Price		Quality, Service	Price	Price	
Market Share Distribution	Fragmented		Fragmented	Concentrated	Concentrated	
Number of Producers	Many		6	27	30	

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*Before-Tax.

**Includes five combined (both mercury and diaphragm) plants.

TABLE 3 (Continued)

PLANT SHUTDOWN DECISION		Treatment Level	ALUMINUM CHLORIDE	ALUMINUM SULFATE	CHLORINE & CAUSTIC SODA (Mercury)	CHLORINE & CAUSTIC SODA (Diaphragm)
Factor	Condition for Shutdown					
Ratio of AT* Treatment Cost to AT* Net Income (%)	High	E.P.P.	8.6	15.7	0.0	2.9
		B.P.T.	8.6	15.7	7.3	2.9
		B.A.T.	8.6	15.7	10.4	6.0
Cash Flow (Including Treatment Costs)	Negative		N.A.	Positive	Positive	Positive
Ratio of Investment in Treatment Facilities to Net Fixed Investment (%)	High	E.P.P.	N.A.	10.0	0.0	0.03
		B.P.T.	N.A.	10.0	1.5	0.72
		B.A.T.	N.A.	10.0	1.9	2.4
Integration	Low		Moderate Forward; Low Backward	Low	High	
Chemical Complex	Isolated Plant		Isolated	Complex and Isolated	Complex	
Other Environmental Problems (Including OSHA)	Multiple		Air Pollution	Solid Waste	Nominal	
Emotional Commitment	Indifference		High	Low to Moderate	Low to High	
Ownership	Multi-Industry Companies		Predominantly Multi-Industry	Multi-Industry	Multi-Industry	

*After-Tax.

TABLE 3 (Continued)

			HYDROCLORIC ACID	HYDROFLUORIC ACID	HYDROGEN PEROXIDE (Electrolytic)	HYDROGEN PEROXIDE (Organic)
1972 Production (M Tons)			2,204	332.2	9	66
1971 Unit Value ($/Ton)			43.2	349.31	596	596
1972 Production Value ($MM)			95.2	112.8	5.4	39.3
Number of Plants (Current)			89	14	1	5
PRICE INCREASE CONSTRAINTS						
Factor	**Condition for Constraint**	**Treatment Level**				
Ratio of BT Treatment Cost to Selling Price (%)	**High**	E.P.P. B.P.T. B.A.T.	0.0 0.2 0.2	0.1 0.4 2.5	0.1 0.2 0.2	0.1 0.1 0.2
Substitute Products	**High Occurrence**		Moderate	Low	Low	
Capacity Utilization	**Low**		ca. 90%	84.5%	70%	
Captive Usage	**Low**		60%	75%	30%	
Demand Growth	**Low**		4%/Yr	5%-7%/Yr	Static	
Foreign Competition	**High**		Low	Low	Moderate	
Abatement Cost Differences	**Unequal**		Unequal	Equal	Unequal	
Price Elasticity of Demand	**High**		Moderate	Low	Low	
Basis for Competition	**Price**		Price	Price	Quality, Service	
Market Share Distribution	**Fragmented**		Fragmented	Concentrated	Concentrated	
Number of Producers	**Many**		42	9	6	

TABLE 3 (Continued)

PLANT SHUTDOWN DECISION			HYDROCHLORIC ACID	HYDROFLUORIC ACID	HYDROGEN PEROXIDE (Electrolytic)	HYDROGEN PEROXIDE (Organic)
Factor	Condition for Shutdown	Treatment Level				
Ratio of AT Treatment Cost to AT Net Income (%)	High	E P.P. B.P.T. B.A.T.	N.A. N.A. N.A.	1.3 3.6 25.4	N.A. N.A. N.A.	N.A. N.A. N.A.
Cash Flow (Including Treatment Costs)	Negative		Positive	Positive	N.A.	
Ratio of Investment in Treatment Facilities to Net Fixed Investment (%)	High	E.P.P. B.P.T. B.A.T.	N.A. N.A. N.A.	0.6 1.0 1.5	N.A. N.A. N.A.	N.A. N.A. N.A.
Integration	Low		High	High Forward	Moderate Forward; Moderate Backward	
Chemical Complex	Isolated Plant		Complex	Complex	Isolated	
Other Environmental Problems (Including OSHA)	Multiple		Air	Nominal	None	
Emotional Commitment	Indifference		High	High	High	
Ownership	Multi-Industry Companies		Multi-Industry	Multi-Industry	Multi-Industry	

TABLE 3 (Continued)

			LIME	NITRIC ACID	SULFURIC ACID (Burning)	SULFURIC ACID (Regen)
1972 Production (M Tons)			20,865	7,000	31,086	
1971 Unit Value ($/Ton)			16	67	21	
1972 Production Value ($MM)			334	441	652.8	
Number of Plants (Current)			170	80	142 Total;	33 Regen
PRICE INCREASE CONSTRAINTS						
Factor	Condition for Constraint	Treatment Level				
Ratio of BT Treatment Cost to Selling Price (%)	High	E.P.P. B.P.T. B.A.T.	8.0 8.0 8.0	N.A. N.A. 0.3	0.2 0.6 0.6	2.3 2.3 2.3
Substitute Products	High Occurrence		Low	Moderate	Moderate	
Capacity Utilization	Low		ca. 95%	85%	65-70% (Fertilizer) 95% (Merchant)	
Captive Usage	Low		35%	90%	60%	
Demand Growth	Low		Moderate	Low	3-4% (Fertilizer) 2-3% (Merchant)	
Foreign Competition	High		Low	Low	Low	
Abatement Cost Differences	Unequal		Unequal	Equal	Unequal	
Price Elasticity of Demand	High		Moderately High	Moderate	Moderate	
Basis for Competition	Price		Price	Price	Price	
Market Share Distribution	Fragmented		Fragmented	Fragmented	Concentrated (Fertilizer) Fragmented (Merchant)	
Number of Producers	Many		110	49	71	

TABLE 3 (Continued)

PLANT SHUTDOWN DECISION						
Factor	Condition for Shutdown	Treatment Level	LIME	NITRIC ACID	SULFURIC ACID (Burning)	SULFURIC ACID (Regen)
Ratio of AT Treatment Cost to AT Net Income (%)	High	E.P.P. B.P.T. B.A.T.	67.0 67.0 67.0	N.A. N.A. N.A.	2.5 6.0 6.0	25 25 25
Cash Flow (Including Treatment Costs)	Negative		*ca*. $2/Ton Depr.	N.A.	Positive	Positive
Ratio of Investment in Treatment Facilities to Net Fixed Investment (%)	High	E.P.P. B.P.T. B.A.T.	N.A. N.A. N.A.	N.A. N.A. N.A.	1.4 3.0 3.0	14.4 14.4 14.4
Integration	Low		Moderate Forward; High Backward	High Forward; Low Backward	Moderate to High	
Chemical Complex	Isolated Plant		Complex and Isolated	Complex	Complex	
Other Environmental Problems (Including OSHA)	Multiple		Air	Air Pollution	Air Pollution	
Emotional Commitment	Indifference		High	Moderate	High	
Ownership	Multi-Industry Companies		Two-thirds are Multi-Industry	Large Multi-Industry; Small Fertilizer and Explosive	Multi-Industry	

TABLE 3 (Continued)

PRICE INCREASE CONSTRAINTS							
Factor	Condition for Constraint	Treatment Level	CALCIUM CARBIDE	SODIUM SULFATE	TITANIUM DIOXIDE (Sulfate)		TITANIUM DIOXIDE (Chloride)
1972 Production (M Tons)			493	1,364	687		
1971 Unit Value ($/Ton)			90	21	452		
1972 Production Value ($MM)			44.4	28.6	343		
Number of Plants (Current)			5	32	6		8
					Neut.	Acid Rec.	
Ratio of BT Treatment Cost to Selling Price (%)	High	E.P.P. B.P.T. B.A.T.	2.2 2.2 2.2	0.0 0.0 0.0	1.4 14.3 16.8	1.5 6.0 8.6	6.4 6.4 11.3
Substitute Products	High Occurrence		High	High	Low		
Capacity Utilization	Low		59%	88%	85%		
Captive Usage	Low		75%	Low	14%		
Demand Growth	Low		Declining	Static	4-5%/Yr		
Foreign Competition	High		Low	Moderate to High	Low		
Abatement Cost Differences	Unequal		Unequal	Unequal	Unequal		
Price Elasticity of Demand	High		Moderately High	High	Low		
Basis for Competition	Price		Price	Price	Technology and Service		
Market Share Distribution	Fragmented		Concentrated	Fragmented	Concentrated		
Number of Producers	Many		4	22	4		7

TABLE 3 (Continued)

PLANT SHUTDOWN DECISION			CALCIUM CARBIDE	SODIUM SULFATE	TITANIUM DIOXIDE (Sulfate)		TITANIUM DIOXIDE (Chloride)
Factor	Condition for Shutdown	Treatment Level			Neut.	Acid Rec.	
Ratio of AT Treatment Cost to AT Net Income (%)	High	E.P.P. B.P.T. B.A.T.	0.0 0.0 0.0	0.0	19.7 198.0 233.0	20.3 82.5 118.0	134 134 237
Cash Flow (Including Treatment Costs)	Negative		N.A.	N.A.	Positive		
Ratio of Investment in Treatment Facilities to Net Fixed Investment (%)	High	E.P.P. B.P.T. B.A.T.	N.A. N.A. N.A.	0.0 0.0 0.0	0.2 48.3 55.6	0.2 19.0 26.3	17.3 17.3 23.5
Integration	Low		Moderate Forward; High Backward	High	Low to Moderate Forward; Moderate Backward		Low to Moderate Forward; Low to Moderate Backward
Chemical Complex	Isolated Plant		Complex and Isolated	Complex	Isolated		
Other Environmental Problems (Including OSHA)	Multiple		Air Pollution	Some Air Pollution	Solid Waste Air (Chloride)		
Emotional Commitment	Indifference		Acetylene Low; Others High	By-product Low; Others High	High		
Ownership	Multi-Industry Companies		Primarily Multi-Industry	Multi-Industry	Multi-Industry		

TABLE 3 (Continued)

			SODIUM CHROMATE AND BICHROMATE	POTASSIUM BICHROMATE	SODIUM BICARBONATE	SOLAR SALT
1972 Production (M Tons)			137.1	3	248	1,799*
1971 Unit Value ($/Ton)			248	475	49	8.40**
1972 Production Value ($MM)			34.9	1.4	12.1	15.1***
Number of Plants (Current)			3	1	4	18
PRICE INCREASE CONSTRAINTS						
Factor	Condition for Constraint	Treatment Level				
Ratio of BT Treatment Cost to Selling Price (%)	High	E.P.P. B.P.T. B.A.T.	4.6 6.6 6.6	0.6 1.0 1.0	0.02 0.02 0.02	0.00 0.00 0.00
Substitute Products	High Occurrence		Many (for derivatives)	Moderate	Low	High
Capacity Utilization	Low		80%	N.A.	94%	High
Captive Usage	Low		35%	Low	Low	Low
Demand Growth	Low		Declining	Low	4½-6%	Static
Foreign Competition	High		High	Moderate	Low	High
Abatement Cost Differences	Unequal		Unequal	---	Equal	None
Price Elasticity of Demand	High		High	High	Low	High
Basis for Competition	Price		Price and Service	Price	Price	Price
Market Share Distribution	Fragmented		Concentrated	Concentrated	Concentrated	Fragmented
Number of Producers	Many		3	1	3	11

*Quantity sold or used by producers.
**Reported 1972 value.
***Value of quantity sold or used by producers.

TABLE 3 (Continued)

PLANT SHUTDOWN DECISION			SODIUM CHROMATE AND BICHROMATE	POTASSIUM BICHROMATE	SODIUM BICARBONATE	SOLAR SALT
Factor	Condition for Shutdown	Treatment Level				
Ratio of AT Treatment Cost to AT Net Income (%)	High	E.P.P. B.P.T. B.A.T.	30.8 43.7 43.7	6.2 9.7 9.7	0.2 0.2 0.2	0.0 0.0 0.0
Cash Flow (Including Treatment Costs)	Negative		Positive	Positive	Positive	Unchanged
Ratio of Investment in Treatment Facilities to Net Fixed Investment (%)	High	E.P.P. B.P.T. B.A.T.	15.8 29.8 29.8	0.5 1.0 1.0	Low Low Low	0.0 0.0 0.0
Integration	Low		Low to Moderate	High Backward; Low Forward	Low	Low
Chemical Complex	Isolated Plant		Isolated	Isolated	Complex	Isolated
Other Environmental Problems (Including OSHA)	Multiple		Multiple	Multiple	Nominal	Multiple
Emotional Commitment	Indifference		High	High	Low to High	Indifference
Ownership	Multi-Industry Companies		Multi-Industry	Multi-Industry	Predominately Multi-Industry	Single-Industry

TABLE 3 (Continued)

PRICE INCREASE CONSTRAINTS Factor	Condition for Constraint	Treatment Level	EVAPORATED SALT	SODIUM SILICATE	SODIUM METAL	SODIUM SULFITE
1972 Production (M Tons)			4,051*	663	159.9	460
1971 Unit Value ($/Ton)			26.94**	86	220	48 Avg./$200 Photo
1972 Production Value ($MM)			109.1	57	33.28	22
Number of Plants (Current)			23	42	5	7***
Ratio of BT Treatment Cost to Selling Price (%)	High	E.P.P.	0.87	0.5	1.0	6 Avg./1.5 Photo Grade
		B.P.T.	1.6	1.0	2.0	6 Avg./1.5 Photo Grade
		B.A.T.	1.6	1.0	2.0	-3 Avg/-.8 Photo Grade****
Substitute Products	High Occurrence		Low	Low	Medium	High General; Low Photo Grade
Capacity Utilization	Low		Low	70% (Low)	85% (High)	90%
Captive Usage	Low		Low	25% (Low)	85% (High)	Low
Demand Growth	Low		2.5% Per Year	Low	Low	Low
Foreign Competition	High		Low	Negligible	Low	Low
Abatement Cost Differences	Unequal		Equal	Equal	Unequal	N.A.
Price Elasticity of Demand	High		Low	Low	Low	Low
Basis for Competition	Price		Price/Service	Price	Price	Price
Market Share Distribution	Fragmented		Fragmented	Fragmented (6 producers control 90%)	Concentrated	Fragmented
Number of Producers	Many		12	10	3	5

*Quantity sold or used by producers.

**Reported 1972 value.

***Plants producing merchant material as by-product and primary product (3 plants primary product--photo grade)--excludes plants producing for captive consumption in NSSC pulp.

****Applicable only to product which is manufactured for merchant market by direct reaction of SO_2 and Na_2CO_3 with subsequent crystallization to obtain dry material.

TABLE 3 (Continued)

PLANT SHUTDOWN DECISION			EVAPORATED SALT	SODIUM SILICATE	SODIUM METAL	SODIUM SULFITE
Factor	Condition for Shutdown	Treatment Level				
Ratio of AT Treatment Cost to AT Net Income (%)	High	E.P.P. B.P.T. B.A.T.	7.3 13.7 13.7	10 20 20	10 25 25	Low Lower Lowest (Negative)
Cash Flow (Including Treatment Costs)	Negative		Positive	Positive	Negative	Negative
Ratio of Investment in Treatment Facilities to Net Fixed Investment (%)	High	E.P.P. B.P.T. B.A.T.	16.9 33.8 33.8	1 2 2	5 5 5	N.A. N.A. N.A.
Integration	Low		Low	Low	High	80% By-product*
Chemical Complex	Isolated Plant		Isolated	Isolated	Isolated	80% By-product*
Other Environmental Problems (Including OSHA)	Multiple		Nominal	N.A.	N.A.	Multiple
Emotional Commitment	Indifference		High	Low	Low-High	Indifference
Ownership	Multi-Industry Companies		Single-Industry	Multi-Industry	Multi-Industry	Multi-Industry

*Estimated 80% of merchant sales are of sodium sulfite obtained as by-product of phenol or resorcinol production.

TABLE 3 (Continued)

			CALCIUM CHLORIDE	SYNTHETIC SODA ASH	POTASSIUM SULFATE	
1972 Production (M Tons) 1971 Unit Value ($/Ton) 1972 Production Value ($MM) Number of Plants (Current)			820 39 32 11	4,301 34.60* 148.8 6	402 42.27 16 6 + Minors	
PRICE INCREASE CONSTRAINTS						
Factor	Condition for Constraint	Treatment Level				
Ratio of BT Treatment Cost to Selling Price (%)	High	E.P.P. B.P.T. B.A.T.	0.5 0.5 0.5	3.4% Profit 0 1.9	5.2 5.2 5.2	
Substitute Products	High Occurrence		Low	High	Moderate	
Capacity Utilization	Low		90%	95%	76% (Nominal 1972)	
Captive Usage	Low		Low	25%	Low	
Demand Growth	Low		Low	Declining	Low	
Foreign Competition	High		Low	Low	Moderate	
Abatement Cost Differences	Unequal		N.A.	Unequal**	Unequal***	
Price Elasticity of Demand	High		Low	High	Low	
Basis for Competition	Price		Price	Price	Price	
Market Share Distribution	Fragmented		Concentrated	Concentrated	Concentrated	
Number of Producers	Many		10	5	5 Plus Minors	

*Reported 1972 value.
**Unequal in comparison with effluent treatment costs for natural soda ash.
***Between production processes--i.e., Hargreaves, Mannheim, Langbeinite, etc.

TABLE 3 (Continued)

PLANT SHUTDOWN DECISION			CALCIUM CHLORIDE	SYNTHETIC SODA ASH	POTASSIUM SULFATE	
Factor	Condition for Shutdown	Treatment Level				
Ratio of AT Treatment Cost to AT Net Income (%)	High	E.P.P.	Low	77% Profit	16	
		B.P.T.	Low	0	16	
		B.A.T.	Low	43.8	16	
Cash Flow (Including Treatment Costs)	Negative		Positive	Positive	Positive	
Ratio of Investment in Treatment Facilities to Net Fixed Investment (%)	High	E.P.P.	2.5	245	8	
		B.P.T.	2.5	0.0	8	
		B.A.T.	2.5	13.7	8	
Integration	Low		By-product	Moderate Forward; Low Backward	High	
Chemical Complex	Isolated Plant		By-product	Complex	Isolated	
Other Environmental Problems (Including OSHA)	Multiple		N.A.	Nominal	N.A.	
Emotional Commitment	Indifference		Moderate	Medium	Low	
Ownership	Multi-Industry Companies		Multi-Industry	Multi-Industry	Multi-Industry	

II. INDUSTRY CHARACTERIZATION--MAJOR STUDY PRODUCTS

A. CALCIUM CARBIDE

1. Summary

Calcium carbide is produced in the United States almost exclusively for conversion to acetylene gas. Acetylene is used primarily in the synthesis of various organic chemicals and plastics, although a significant amount is used as a fuel for welding and other metalwork.

Production of calcium carbide declined more than 50% by 1972 from a peak reached in the mid-1960's. The main reason for this decline has been the substitution of acetylene derived from hydrocarbons for that produced from calcium carbide for the manufacture of organic chemicals. Acetylene for chemical uses has also been largely replaced by other, less expensive, raw materials.

While the lower cost of shipping calcium carbide to industrial centers for conversion to fuel acetylene has favored this source over tanked, hydrocarbon-derived acetylene, more convenient and economical fuels (e.g., propane) have made significant inroads into the amount of acetylene used for metalworking.

The general trend of a declining market for calcium carbide is likely to continue as hydrocarbon-derived acetylene replaces carbide-derived acetylene for chemical use, and as other raw materials replace acetylene in both chemical and metalworking applications.

2. Market Characterization

a. Size

U.S. production of calcium carbide reached a maximum of approximately 1.1 million tons per year in the period 1960 to 1965. Since U.S. foreign trade in this commodity has always been small in comparison to production, apparent annual consumption of calcium carbide was also at a level of about 1.1 million tons during this period, as is shown in Table 4. By 1972, production had fallen to less than half a million tons per year. Table 4 also indicates the low level of imports, which have ranged between 1% and 3% of consumption in recent years, and have come exclusively from Canada.

b. Growth

Calcium carbide producers have experienced a steady drop in demand for almost a decade. Annual market value data for calcium carbide production since 1950 are given in Table 5. While 1972 production, at

TABLE 4

CALCIUM CARBIDE PRODUCTION, IMPORT/EXPORT, AND APPARENT CONSUMPTION
(Thousands of Tons)

Year	Production	Imports	Exports[1]	Apparent Consumption[2]
1950	671	6	6	671
1955	875	2	4	873
1960	1,093	5	5	1,093
1961	1,042	5	6	1,041
1962	1,083	6	6	1,083
1963	1,109	7	6	1,110
1964	1,132	12	6	1,138
1965	1,098	11	-	1,109
1966	1,063	20	-	1,083
1967	912	8	-	920
1968	942	7	-	949
1969	856	18	-	874
1970	791	19	-	810
1971	625	20	-	645
1972	493	11	-	504

[1] Exports not reported separately after 1964.

[2] Apparent consumption: production and imports minus exports.

Source: U.S. Department of Commerce.

TABLE 5

TOTAL MARKET VALUE OF CALCIUM CARBIDE PRODUCTION

Year	Production (Thousands of Tons)	Market Value ($/Ton)	Total Market Value ($MM)
1950	671	78	52.3
1955	875	94	82.3
1960	1,093	100	109.3
1961	1,042	99	103.5
1962	1,083	93	101.0
1963	1,109	95	104.9
1964	1,132	91	102.8
1965	1,098	89	97.7
1966	1,063	87	92.5
1967	912	94	85.7
1968	942	94	88.5
1969	856	78	66.8
1970	791	81	64.1
1971	625	90	56.3
1972	493	90 (est.)	44.4

Sources: U.S. Department of Commerce, and Contractor's estimates.

493,000 tons represented a 55% drop from 1960 production levels, price erosion has caused the total market value of calcium carbide production to drop 60% over the same period (from $109 million to $44 million).

c. Uses

Although a small quantity of calcium carbide is consumed in such direct applications as the carburization of steel, desulfurization, and other foundry work, by far the largest use is in the production of acetylene. In the preferred "dry" process, water is added to calcium carbide to form acetylene and calcium hydroxide at the rate of 640 pounds of acetylene per ton of carbide. The "wet" process uses excess water, and produces by-product calcium hydroxide in a slurry which is 90% water.

Approximately 80% of the acetylene produced from calcium carbide is used as a raw material in the synthesis of organic chemicals and plastics by the chemical industry. The balance is used as a fuel in metalworking for welding, cutting, and scarfing. A summary of calcium carbide use, showing representative products produced by the chemical industry, is given in Table 6.

d. Substitute Products

Until 1951, all of the acetylene produced in the United States was derived from calcium carbide. Since that time, acetylene has also been manufactured through the pyrolysis, or cracking, of hydrocarbons. This process produces several other important industrial chemicals as by-products, and has become increasingly competitive with the calcium carbide route to acetylene.

The advantage of calcium carbide as a source of acetylene is that the carbide can be shipped more economically than the heavy cylinders of compressed acetylene gas. Thus, for uses which are geographically removed from the production of hydrocarbon-derived acetylene, calcium carbide as a source of acetylene is less-susceptible to substitution. Even here, however, carbide acetylene faces competition from other fuels, such as propane or natural gas, and also from electric-arc welding.

In such direct applications as the carburization of steel, desulfurization, and use as a drying agent, calcium carbide also faces competition from a variety of products. In foundry work, various combinations of lime, coke, and magnesium can replace calcium carbide. Calcium sulfate is only one example among a variety of alternative drying agents which are available as substitutes for calcium carbide. These direct applications currently account for only about 3% of U.S. consumption.

e. Geographic Consumption

Except for the relatively small amount of calcium carbide used to generate acetylene for metalworking, virtually all calcium carbide

TABLE 6

USE PATTERN OF CALCIUM CARBIDE BY APPLICATION[1]

Calcium Carbide Converted to Acetylene		97%
Chemical Acetylene	80%	
Used in synthesis of organic chemicals (e.g., butadiene, allyl alcohol, vinyl ethers) and derived products such as neoprene, other plastics, and resins.		
Fuel Acetylene	17%	
Used for welding, cutting and scarfing in metalwork, and for production of acetylene black.		
Calcium Carbide for Direct Use		3%
Includes use as a dehydrating agent and a reducing and desulfurizing agent in certain metallurgical processes.		
		100%

[1] This use pattern is typical of consumption in 1972. Chemical use of calcium carbide acetylene is rapidly becoming much less significant.

Sources: Kirk-Othmer, Encyclopedia of Chemical Technology; Shreve, Chemical Process Industries; and Contractor's estimates.

is consumed in the region in which it is produced. In fact, most carbide acetylene is generated either in the same plant as the carbide, or in an adjacent one. In 1972, nearly 85% of U.S. calcium carbide production capacity was located in Kentucky and Ohio, and with it, the bulk of calcium carbide consumption. Most of the remaining 15% of consumption occurs in major industrial metalworking cities such as Cleveland, Detroit, and Pittsburgh.

f. Captive Requirements

As indicated above, calcium carbide is most often used as a ready source of acetylene. Furthermore, the greatest portion of calcium carbide is consumed either in the same plant as it is produced, or at another plant owned by the same company. Although the most recent information on merchant shipments was given in 1965, it is apparent from these data that captive consumption was typically at a level of 75%. Data illustrating this relationship for the years 1962 through 1965 are given in Table 7. Although the trend in recent years has been away from captive use, as acetylene for chemical synthesis has been replaced by ethylene, propylene, and other less expensive raw materials, the bulk of calcium carbide production will be consumed captively throughout the 1970's.

3. Supply Characterization

a. Manufacturing Route

Calcium carbide is prepared from quicklime (calcium oxide) and coke (carbon) which are mixed together at approximately 2000° C. This temperature is achieved in an electric furnace using large amounts of electric power. In a typical run, 1900 pounds of quicklime, 1300 pounds of coke, and 3,000 kilowatt hours of electricity are required to produce one ton of calcium carbide. The product, tapped from the furnace as a liquid, is allowed to solidify and is then crushed to a convenient size for packing and handling. Calcium carbide for chemical acetylene often goes directly to an acetylene generator in the same plant.

An example of the overall process is shown in Figure 3 as a simplified schematic diagram. The source of quicklime is a high-grade limestone containing nearly 100% calcium carbonate. The limestone is heated in a kiln to produce quicklime, which is combined with coke, or another source of carbon such as anthracite, in the electric furnace. The large power requirements and high raw material shipping costs are important factors in determining plant location.

b. Producers

In 1972, calcium carbide was produced in seven plants by four different companies. As indicated in Table 8, three of these plants

TABLE 7

CAPTIVE VS. COMMERCIAL CONSUMPTION OF CALCIUM CARBIDE
(Thousands of Tons)

		Consumption		
Year	Production	Captive	Merchant[1]	Percent Captive
1962	1,083	815	268	75
1963	1,109	824	285	74
1964	1,132	891	241	79
1965	1,098	819	279	75

[1] Last reported separately in 1965.

Source: U.S. Department of Commerce.

FIGURE 3

SCHEMATIC FLOW DIAGRAM--PRODUCTION OF CALCIUM CARBIDE

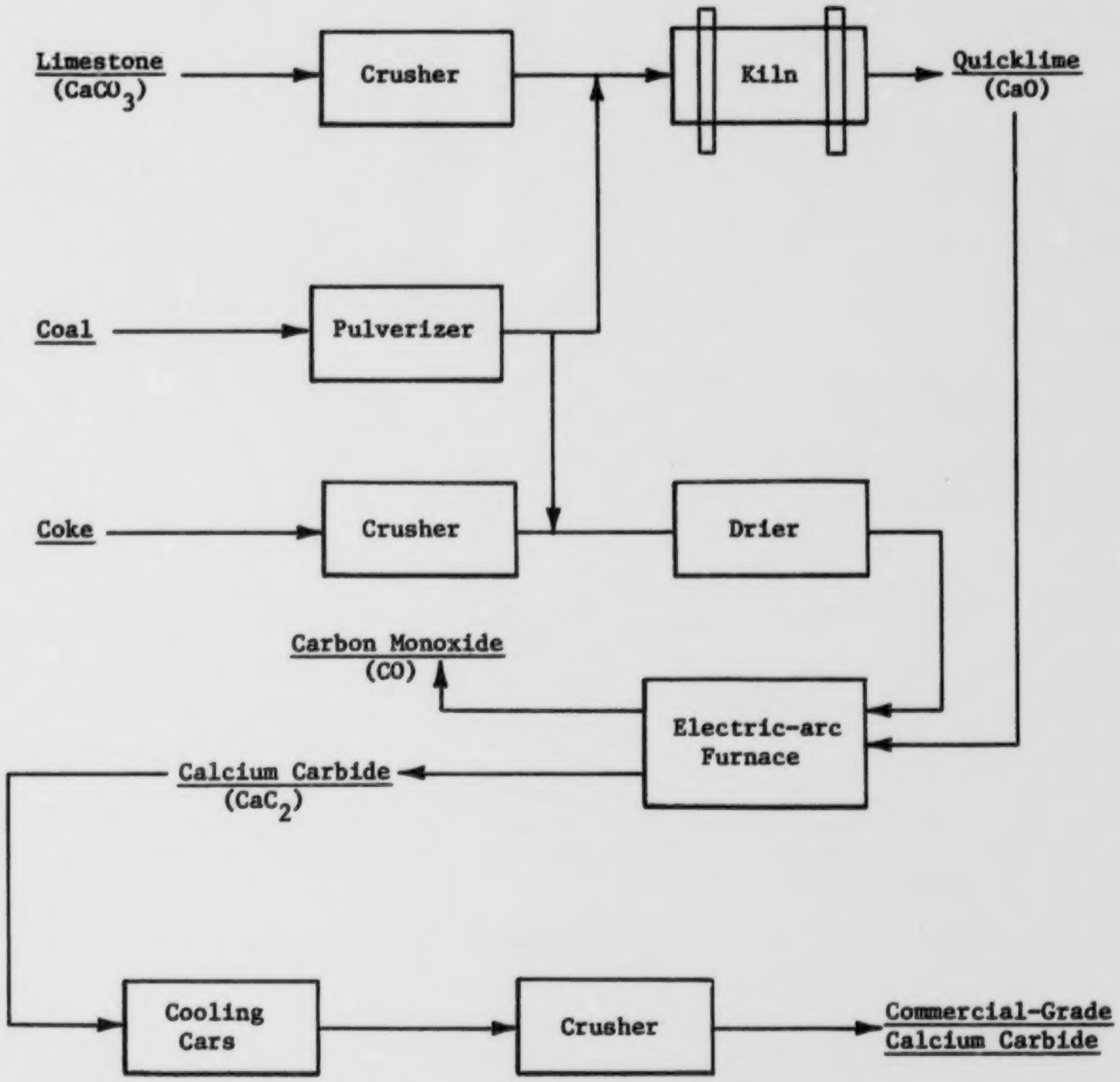

Limestone
($CaCO_3$)
Crusher
Kiln
Quicklime
(CaO)
Coal
Pulverizer
Coke
Crusher
Drier
Carbon Monoxide
(CO)
Electric-arc Furnace
Calcium Carbide
(CaC_2)
Cooling Cars
Crusher
Commercial-Grade Calcium Carbide

TABLE 8

CALCIUM CARBIDE PRODUCERS--LOCATION AND CAPACITY
(Thousands of Tons)

Producer	Location	Annual Capacity
Airco, Inc.	Calvert City, Ky.	325
Airco Carbide Div.[1]	Louisville, Ky.	150
Midwest Carbide Corp.	Keokuk, Iowa	30
	Pryor, Okla.	50
Pacific Carbide & Alloys Co.	Portland, Ore.	20
Union Carbide Corp.[2]		
Chemicals & Plastics Div.	Ashtabula, Ohio	228
	Portland, Ore.	35
Total		838

[1] Manufacturing operations in Calvert City were discontinued early in 1973; the Louisville plant is to be phased out over the next several years.

[2] Operations at Portland were discontinued in mid-1973.

Sources: Trade journals, industry contacts.

were responsible for most (84%) of the 1972 annual production capacity of 838,000 tons. These were the Airco plants at Calvert City and Louisville, Kentucky, and the Union Carbide plant at Ashtabula, Ohio.

A decade ago, in 1960, there were twelve plants, with a combined capacity of 1,225,000 tons. The move to reduce capacity, which began in the early 1960's, has continued into 1973 with the announcement by Airco that operations would be discontinued at the Calvert City plant, and that the Louisville plant would be phased out by about 1980. The closing of Calvert City has reduced 1973 U.S. capacity by 39% to approximately 513,000 tons per year.

Existing calcium carbide plants may be classified as either large (annual capacity 150,000 tons or more), or small (annual capacity 50,000 tons or less), with four of the six plants operating in early 1973 classified as small. All of these plants are at least ten years old and some are much older. Airco's Calvert City plant had been operating about 20 years when it closed this year.

As stated earlier, approximately 75% of all calcium carbide produced is captively consumed. This gives some indication of the large degree of intra- and inter-company integration in the sale and use of this chemical commodity. As an example, the Airco plant at Calvert City, which was the largest calcium carbide plant in the world, shipped a small part of its output to the Airco plant in Louisville, and converted the rest to acetylene for local use. This local use included chemical synthesis at an adjacent Airco plant, and shipment of acetylene and derived products by pipeline to the plants of several other firms in the large Calvert City chemical complex.

c. Manufacturing Economics

A summary of estimated manufacturing costs for calcium carbide is given in Table 9. The data in this table are for a plant of 45,000 ton-per-year annual capacity, operating at 100% capacity. A plant of double this capacity would benefit from relatively small economics of scale, reducing manufacturing costs by about 5%, to $81 per ton. On the other hand, a plant producing calcium carbide for fuel acetylene, as opposed to chemical acetylene, experiences manufacturing costs which may be from 5% to 6% higher than that shown in Table 9 due to quality requirements relating both to raw materials and to the manufacturing process itself. General, selling, and administrative expenses are estimated to be 5% of manufacturing costs. This brings total costs to about $90 per ton for a 45,000 ton-per-year plant producing calcium carbide for conversion to chemical acetylene. Depending on plant size and intended end use of the product, total manufacturers' costs may vary from approximately $85 to $95 per ton.

TABLE 9

ESTIMATED COST OF MANUFACTURING CALCIUM CARBIDE

Plant Capacity: 45,000 Tons/Yr (1-15,000 KVA furnace)
Fixed Investment: $3,740,000

	Quantity/Ton	$/Unit	$/Ton
Variable Costs			
Quicklime	0.95 ton	18.75	17.81
Coke	0.65 ton	24.00	15.60
Carbon Electrodes	30 lb.	0.15	4.50
Operating Supplies			0.30
Power	2780 kwh	0.007	19.46
Water	32 M gal	0.02	0.64
			58.31
Semi-Variable & Fixed Costs			
Operating Labor	9 men/shift	4.25/hr	7.45
Supervision	4 foremen	12,000/yr	1.07
	1 superintendent	17,000/yr	0.38
Maintenance	4½% of investment/yr		3.73
Labor Overhead	30% of operating labor and supervision		2.67
Plant Overhead	70% of operating labor and supervision		6.23
Depreciation[1]	6-2/3% of investment/yr		5.53
Local Taxes & Insurance	1½% of investment/yr		1.25
			28.31
Cost of Manufacture (Bulk)			86.62
Off Gas Credit[2]	3.14 MM Btu	0.35	(1.10)
Net Cost of Manufacture[3] (Bulk)			85.52

[1] For older plants depreciation may only cover items replaced and be about 20% of this amount.

[2] Credit valid only if carbon monoxide can be utilized as fuel at plant.

[3] Quality requirements make manufacturing costs about $5/ton higher for manufacturers of calcium carbide for use in generation of fuel acetylene.

4. Supply/Demand Balance

Industry capacity for calcium carbide has gradually been reduced since the early 1960's. As of 1972, capacity had been reduced by 30%, while production had fallen by more than 50%. In the early 1960's, operating rates were typically close to 90% of capacity; in the early 1970's operating rates have generally been below 80%, and it is only the shut down of the largest plant in the industry (Calvert City) which has brought current capacity down to a level consistent with current demand.

In view of the continued replacement of carbide acetylene by hydrocarbon-derived acetylene, and replacement of acetylene for chemical use by less expensive raw materials, this trend towards reduction of excess capacity is likely to continue as demand is further reduced. Total production in the first two months of 1973, for example, was 20% below that of the same period in 1972.

5. Prices

Published prices for packaged and delivered calcium carbide have increased steadily from $121 per ton in the early 1950's, to a level of $171 per ton since 1963. A more realistic price for 1972 is the $100 per ton, f.o.b. plant, quoted by industry sources. Some discounting occurs, and the average actual price received for calcium carbide shipments has been somewhat lower than this in recent years, as is shown in Table 10. In addition to discounting, and as indicated in the footnote for Table 10, the difference between actual and published prices also reflects packaging and freight charges. Packaging charges range from $35 to $45 per ton, and freight charges add approximately $10 per ton locally and up to $20 per ton for more distant shipments within a given region.

Information on 1972 actual prices is not yet available, but it appears that the declining trend was at least temporarily halted in 1971 when actual price increased approximately 10%, from $81.00 to $90.00 per ton. In any case, a comparison of manufacturer's total costs with actual prices received per ton of calcium carbide, indicates that U.S. producers of this chemical are currently operating at, or near, the break-even level.

TABLE 10

CALCIUM CARBIDE PRICES--PUBLISHED VS. ACTUAL
(Dollars per Ton)

Year	Published Price[1]	Actual Price[2]
1950	121	78
1955	134	94
1960	149	100
1965	171	89
1970	171	81
1971	171	90
1972	171	N.A.

[1] Published prices include packaging and freight charges of ca. $50/ton. Quoted 1972 price for bulk calcium carbide was $100 per ton, f.o.b. plant.

[2] Actual Price: Total Value of Shipments/Tons Shipped.

Sources: Chemical Marketing Reporter, U.S. Department of Commerce, and Contractor's estimates.

B. SODIUM SULFATE

1. Summary

Sodium sulfate is produced in the United States largely as a joint product with some other material, rather than for its own value. This joint-product characteristic, combined with a low price, has often led to a situation where the potential supply of sodium sulfate has exceeded demand. Uses have been developed to take advantage of the large, inexpensive supplies. As a result sodium sulfate has become an important material to several industries, and its low cost ultimately translates to lower product costs in those industries where it is used.

Sodium sulfate is used in the paper industry, by detergent manufacturers, and in the manufacture of glass and textiles. U.S. consumption has averaged 1.6 million tons over the last decade, and this level of use is likely to be characteristic of the foreseeable future.

2. Market Characterization

a. Size

U.S. production of sodium sulfate was approximately 1.36 million tons in 1972, down 8% from a record level of nearly 1.5 million tons in 1968. Total value of 1971 shipments was $28 million.

Net imports of about 0.27 million tons in 1972 (equal to 20% of U.S. production) brought total 1972 U.S. apparent consumption to approximately 1.63 million tons. Belgium accounted for 48% of import dollar value, Canada 38%, and in descending order of importance, The Netherlands, East Germany, Sweden, West Germany, and Japan accounted for the remaining 14%.

Historical data for production, foreign trade, and apparent consumption are given in Table 11. In this table, and in Table 17. (giving price information) the data are presented for both high purity (anhydrous sodium sulfate), and lower purity (saltcake) grades of sodium sulfate. Most of this analysis will be in terms of aggregate data for both grades.

b. Growth

As Table 11 illustrates, both U.S. production and apparent consumption of sodium sulfate reached record levels in 1968. Between 1968 and 1972, production decreased 8% and apparent consumption

TABLE 11

SODIUM SULFATE PRODUCTION, IMPORT/EXPORT, AND APPARENT CONSUMPTION

(Thousands of Tons--100% Na_2SO_4)

	Production, by Type[1]		Foreign Trade[2]		
Year	Saltcake	Anhydrous Na_2SO_4	Imports	Exports	Apparent Consumption[3]
1960	810	303	167	31	1249
1961	844	327	196	32	1335
1962	826	368	188	51	1331
1963	837	396	160	45	1348
1964	926	390	290	44	1562
1965	976	428	274	13	1665
1966	1,009	436	237	28	1654
1967	696	668	290	28	1626
1968	758	725	305	56	1732
1969	730	744	286	91	1669
1970	561	812	269	55	1587
1971	514	843	269	67	1559
1972	681	683	299	29	1634

[1] The large difference between pre-1967 and post-1966 production figures is due to a product classification change.

[2] Total for crude and refined sodium sulfate.

[3] Apparent Consumption: production plus imports minus exports.

Source: U.S. Department of Commerce. Data for 1972 are preliminary.

decreased 6%. Data for 1972 indicate that the downward trend has at least temporarily stopped. Production volume was up slightly (less than 1%) from 1971, and apparent consumption increased 5%.

While net imports were at a record level in 1972, and accounted for most of the 5% increase in apparent consumption between 1971 and 1972, it is difficult to discern a trend in imports over the past decade. From a low of 9% to a high of 20%, net imports have averaged 16% of U.S. production since 1962.

c. Uses

An estimated use pattern for sodium sulfate is given in Table 12. By far the largest use (ca. 70%) is in the kraft, or sulfate, pulping process of the paper industry. Sodium sulfate is converted to sodium sulfide, and with sodium hydroxide and water, forms a digesting solution for wood chips. Techniques for recovering impure sodium sulfate (saltcake) from the digesting liquor are constantly being improved, but present losses average about 100 pounds of saltcake per ton of pulp. Purchased saltcake is used to replace that which is not currently recovered. Use in kraft pulping has remained relatively constant at about 1.1 million tons for the last ten years. Increasing requirements due to growing pulp demand have been offset by improved sodium sulfate recovery techniques.

The second largest use of sodium sulfate (ca. 18%) is in detergent formulations. A small amount is added to all detergents as part of the manufacturing process, but increasingly, manufacturers have been adding additional purchased sodium sulfate to their formulations. This additional sodium sulfate partly compensates for the loss of bulk and detergency brought about by decreased phosphate content. Sodium sulfate use in detergent formulation has doubled from about 150,000 tons in the early 1960's to about 300,000 tons in 1972.

Use in the manufacture of glass, in textile finishing, and other uses constitute the remainder (ca. 12%) of U.S. consumption of sodium sulfate. In glass manufacture, sodium sulfate speeds the melting of the raw material charge, improves the working properties of high-silica glass, and, when carbon is added, forms sulfur dioxide gas. The sulfur dioxide bubbles have a "fining" effect, removing other gas bubbles as they move toward the surface of the molten glass.

Use of sodium sulfate in glass manufacture has decreased slightly over the past decade due to restrictions on the sulfur dioxide content of stack gases. Manufacturers are being forced to cut down on the amount of sodium sulfate in each batch of glass and to install scrubbing units which will allow recycling of sodium sulfate. Current consumption is about 140,000 tons per year.

In textile manufacture, sodium sulfate finds use in the finishing operation. The primary use is dye standardization; that is,

TABLE 12

USE PATTERN OF SODIUM SULFATE BY APPLICATION

Kraft (Sulfate) Paper Process	Used with sodium sulfide and sodium hydroxide in the pulping-bleaching operation.	70%
Detergents	Sodium sulfate is used in detergents to improve detergency and contribute bulk density to the formulation.	18%
Glass, Textile, and Other	In approximate order of importance, sodium sulfate is used in "fining" glass, standardizing textile dyes, manufacturing cellulose sponges, as a cleaning and metal pickling agent, in mineral feed supplements, and in photography.	12%
		100%

Sources: Kirk-Othmer, *Encyclopedia of Chemical Technology*; Shreve, *Chemical Process Industries*; and Contractor's estimates.

dilution of the dye to a standard potency. Sodium sulfate is also added to the dye bath to level, or control, the color. Consumption of sodium sulfate for textile applications has remained fairly constant at an estimated 50,000 tons annually over the past several years.

Finally, several thousand tons per year of sodium sulfate find application in such uses as cellulose sponge manufacture, mineral feed supplements, cleansing agents, photography, and as a chemical catalyst.

d. Substitute Products

In applications which account for the bulk of U.S. sodium sulfate consumption, other products could be substituted with relative ease. The major consequence of such substitution would probably be increased manufacturing and product costs.

In kraft pulping operations, sodium sulfate is employed as the most economical source of make-up sodium and sulfur values. Other, more-expensive sources (e.g., sodium carbonate or caustic soda) could be substituted for the purchased saltcake, or "synthetic saltcake" may be manufactured by oxidizing a mixture of soda ash (sodium carbonate) and sulfur. Furthermore, the newer pulp mills will generate most, or all, of their saltcake requirements internally as a by-product of on-site chlorine dioxide bleach production. The only problem here is that sodium values must still be purchased outside, and high prices for sodium hydroxide or sodium carbonate can make this source of saltcake less attractive than purchased saltcake.

Increasing use of sodium sulfate in detergent formulation is, itself, the result of a substitution. Sodium sulfate, as an inexpensive electrolite, serves to replace some of the lost detergency and bulk to detergents with reduced phosphate content.

e. Geographic Consumption

An estimated geographic use pattern for sodium sulfate is given in Table 13. More than 60% of sodium sulfate demand is in the U.S. south, and approximately 90% of this demand is attributable to the kraft pulping industry.

Approximately 16% of U.S. sodium sulfate demand is in the north-central--Great Lakes region. The primary use in this region (ca. 60%) is in detergent formulation, with kraft pulping operations accounting for most of the remaining consumption.

The U.S. west and northwest require an estimated 14% of annual U.S. sodium sulfate supply. Kraft mills account for most (ca. 75%) of this regional demand; detergent formulation and other uses make up the rest.

In the U.S. northeast, it is estimated that half of the 7% regional consumption is for detergent formulations; most of the remaining half is split between kraft pulping and glass manufacture.

TABLE 13

GEOGRAPHIC USE PATTERN OF SODIUM SULFATE

South Approximately 90% - kraft pulping, 10% other.	63%
North Central - Great Lakes Approximately 60% - detergent formulation, 25% kraft pulping, 15% other.	16%
West and Northwest Approximately 75% - kraft pulping, 15% detergent formulation, 10% other.	14%
Northeast Approximately 50% - detergent formulation, 20% - kraft pulping, 20% glass fining, 10% other.	7%
	100%

Source: Contractor's estimates.

f. Captive Requirements

Production of sodium sulfate for captive use by producing companies is insignificant in the U.S. Nearly 90% of U.S. production is as by-product or co-product sodium sulfate. The small amount produced as primary product is produced for sale to end users. Table 14 shows a comparison of sodium sulfate production and shipments for the years 1962-1972. Shipments have averaged 99% of production over the last decade.

Production of by-product sodium sulfate during chlorine dioxide bleach manufacture at pulp mills, is the only significant case where by-product sodium sulfate is used in another operation by the same company.

g. Other Market Characteristics

Most of the sodium sulfate produced in the U.S. sells for about $20 per ton, with price as the main basis for competition. In this price range, freight costs become a significant consideration in marketing and distribution of the product. Local shipment may cost up to $15 per ton, and long distance shipping rates may be $24 per ton and more. These rates are relatively high compared to transatlantic bulk shipping rates of about $7 per ton, and allow foreign producers to compete effectively with U.S. companies located on the Atlantic coast.

Within the U.S., the relatively high freight costs cause local demand to be highly dependent on the proximity of sodium sulfate supply. Substitution may occur when freight-equalized costs of another product make its use more economical. An example is caustic soda as a source of sodium values for kraft pulping operations.

3. Supply Characterization

a. Manufacturing Routes

Sodium sulfate has rarely been produced in quantity for its own sake. A summary of sodium sulfate production by process, from 1964 to 1971, is given in Table 15. Only about one-third of the production classified as "natural" is recovered solely for sodium sulfate value, and in 1972, approximately 90% of U.S. production could be classified as by-product or co-product sodium sulfate.

By-product sodium sulfate is defined as sodium sulfate formed in a process which produces one or more other products of significantly higher value. These processes include manufacture of rayon and cellophane, lithium and strontium processing, and the chemical synthesis of sodium bichromate and resorcinol.

Co-product sodium sulfate is formed in a process which concurrently produces products having a value comparable to that of sodium

TABLE 14

CAPTIVE VS. COMMERCIAL CONSUMPTION OF SODIUM SULFATE
(Thousands of Tons)

Year	Production	Shipments[1]
1962	1,194	1,170
1963	1,233	1,226
1964	1,316	1,303
1965	1,404	1,364
1966	1,445	1,398
1967	1,364	1,384
1968	1,483	1,469
1969	1,475	1,439
1970	1,373	1,386
1971	1,356	1,377
1972	1,364	- -

[1] Including interplant transfers.

Source: Current Industrial Reports, U.S. Department of Commerce.

Table 15

PRODUCTION OF SODIUM SULFATE BY PROCESS
(Thousands of Tons)

Year	Mannheim Furnace	Polymer By-Product	Sodium Dichromate and Other	Natural	Total
1964	214	356	201	544	1,315
1965	224	382	190	608	1,404
1966	228	387	217	613	1,445
1967	196	346	228	594	1,364
1968	165	404	254	660	1,483
1969	181	388	282	624	1,475
1970	177	354	278	564	1,373
1971	162	362	210	622	1,356

Source: U.S. Department of Commerce.

sulfate. Examples of such processes are the Mannheim and Hargreaves processes for producing hydrochloric acid, and the recovery of sodium sulfate from natural brines and salts which contain a variety of inorganics of similar value.

One producer, with about 10% of U.S. capacity, has plants which sell sodium sulfate recovered from natural brines as their sole source of revenue. This is the only significant case in which sodium sulfate is produced as a primary product.

Methods for sodium sulfate production may be divided into three categories: recovery from natural sources, production as a by-product of rayon and cellophane manufacture, and production accompanying the synthesis of various chemicals.

Recovery from natural brines accounts for about half of U.S. sodium sulfate production. Figure 4 illustrates, in flow chart form, a typical process for recovery of both anhydrous sodium sulfate and Glauber's salt, a hydrated form of sodium sulfate. The natural brine, containing dissolved sodium sulfate and other inorganics, is pumped into a natural salt deposit to reduce the solubility of sodium sulfate. When the saturated solution is cooled, Glauber's salt precipitates. The mixture is filtered, and the hydrated sodium sulfate is collected for direct sale or for further processing to anhydrous sodium sulfate.

Production of sodium sulfate as a by-product of viscose rayon or cellophane production is responsible for about 30% of U.S. sodium sulfate capacity. Figure 5 is a schematic diagram for production of sodium sulfate as a rayon by-product. The sodium sulfate is formed in a spinning bath when the basic viscose rayon dope is forced through the fine holes of a spinneret into a solution containing sulfuric acid. Sodium sulfate is produced at a rate of about 1.2 pounds per pound of rayon or cellophane. The spinning bath must be refreshed periodically by removing the sodium sulfate which has formed and replenishing the sulfuric acid.

The production of certain industrial chemicals results in the formation of sodium sulfate as a natural result of the process used. Approximately 20% of U.S. sodium sulfate capacity is of this type. Figure 6 is a simple flow diagram for the Mannheim hydrochloric acid process. Salt (sodium chloride) and sulfuric acid are heated together to form hydrogen chloride and crude sodium sulfate. The crude sodium sulfate may be further refined or converted to Glauber's salt depending on relative demand for the two products.

Other examples in this third category of sodium sulfate production include the Hargreaves process for hydrochloric acid, formation with sodium bichromate when sodium chromate is treated with sulfuric acid, and production accompanying the synthesis of phenol and resorcinol.

b. Producers

In 1972 there were 22 companies producing sodium sulfate in 32 locations. These companies, plant locations and capacities, and

FIGURE 4

RECOVERY OF SODIUM SULFATE FROM NATURAL BRINES

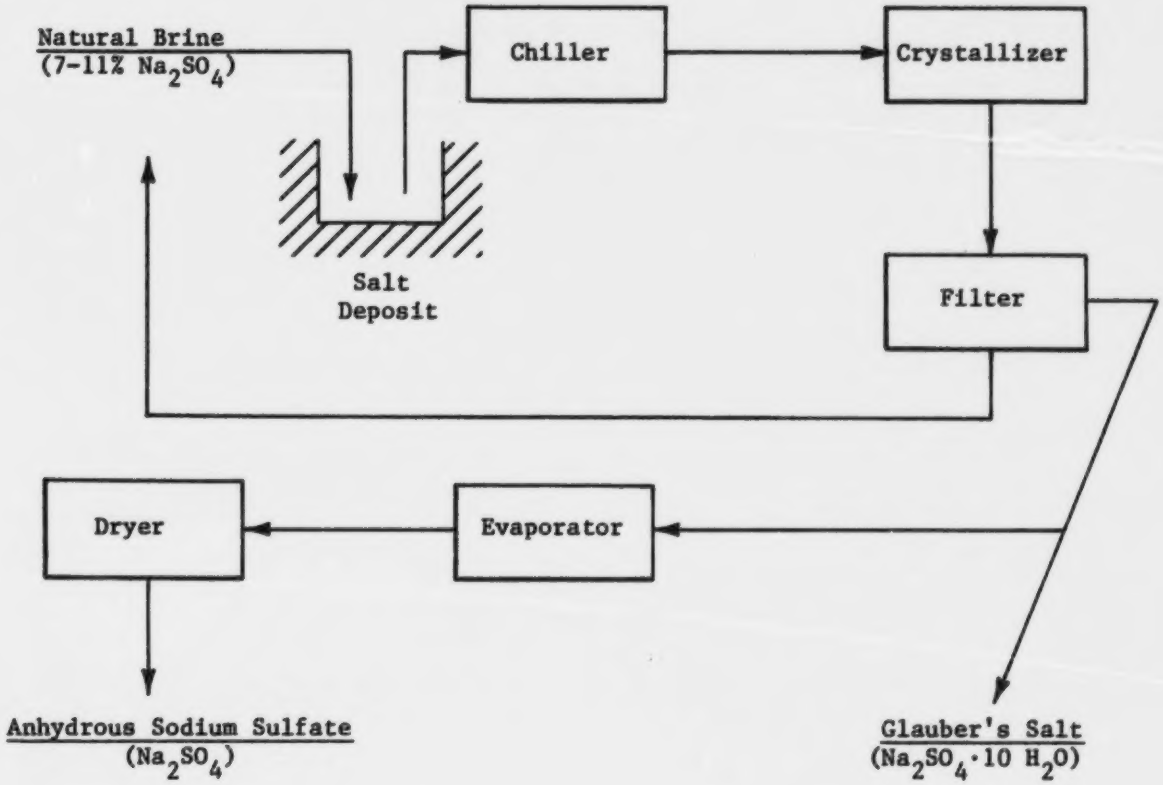

Natural Brine
(7-11% Na_2SO_4)
Chiller
Crystallizer
Salt
Deposit
Filter
Dryer
Evaporator
Anhydrous Sodium Sulfate
(Na_2SO_4)
Glauber's Salt
($Na_2SO_4 \cdot 10\ H_2O$)

FIGURE 5

PRODUCTION OF SODIUM SULFATE IN VISCOSE RAYON PROCESS

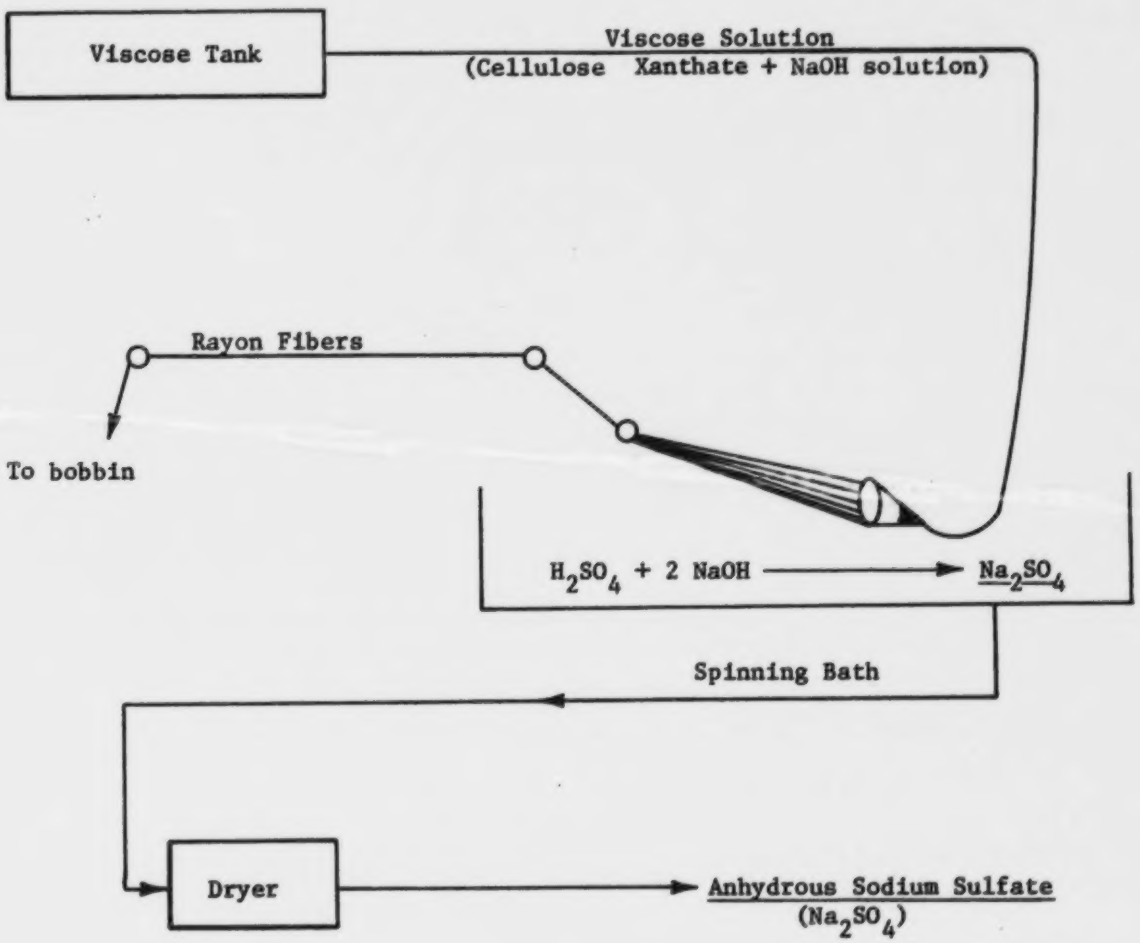
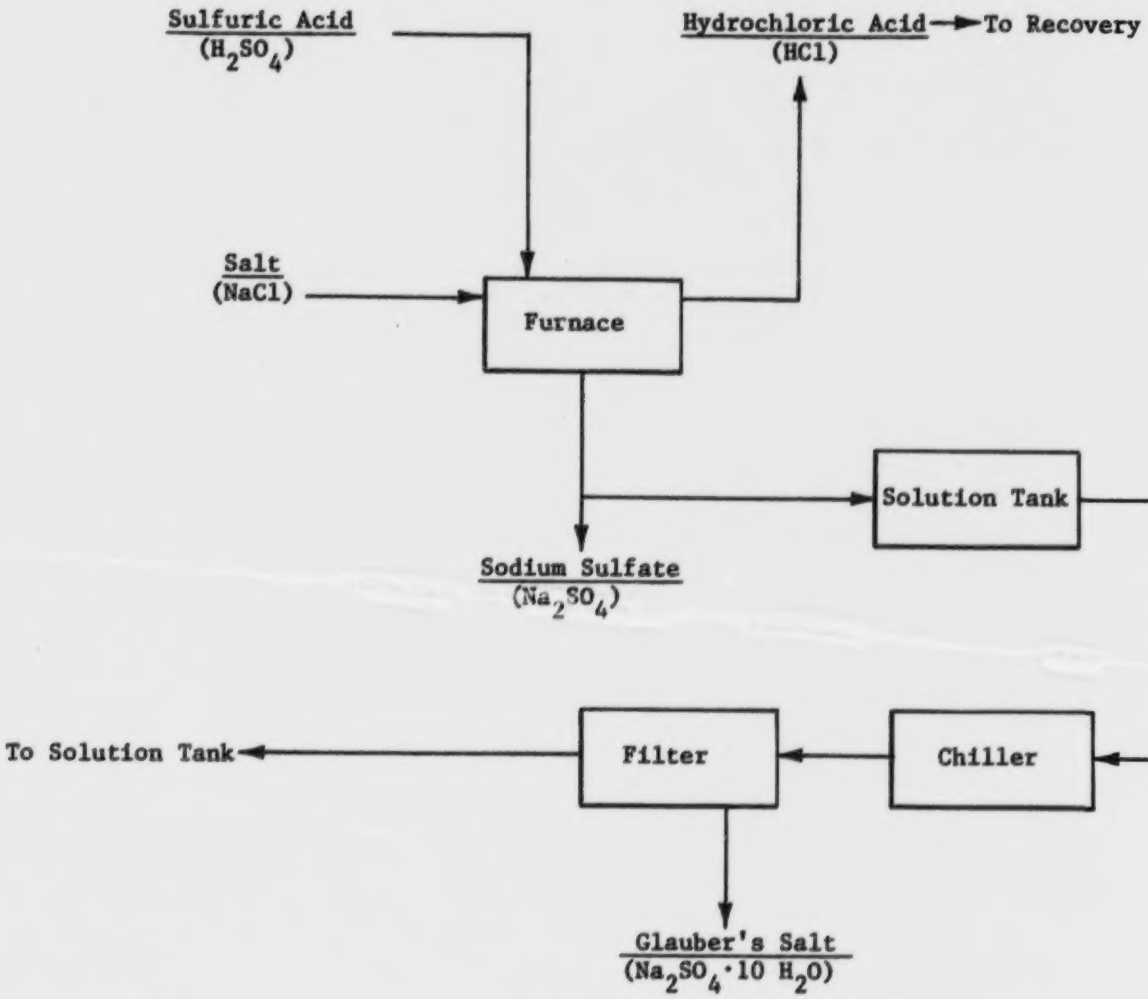

Viscose Tank
Viscose Solution
(Cellulose Xanthate + NaOH solution)
Rayon Fibers
To bobbin
$H_2SO_4 + 2\ NaOH \longrightarrow Na_2SO_4$
Spinning Bath
Dryer
Anhydrous Sodium Sulfate
(Na_2SO_4)

FIGURE 6

PRODUCTION OF SODIUM SULFATE IN THE MANNHEIM PROCESS


Sulfuric Acid
(H_2SO_4)
Hydrochloric Acid
(HCl)
To Recovery
Salt
(NaCl)
Furnace
Solution Tank
Sodium Sulfate
(Na_2SO_4)
To Solution Tank
Filter
Chiller
Glauber's Salt
($Na_2SO_4 \cdot 10\ H_2O$)

processes involved are given in Table 16. The five major producers accounted for 70% of 1972 U.S. capacity. Seven companies (10 plants) produce sodium sulfate from natural sources. Only one of these companies has facilities (2 plants) which produce sodium sulfate as their sole source of operating revenue. The others produce it as either a by-product or co-product along with other inorganics.

Five companies (11 plants) produce sodium sulfate as a by-product of rayon or cellaphane manufacture, and ten companies (11 plants) produce sodium sulfate as a by-product or co-product of chemical synthesis operations.

Seven plants having approximately 100,000 tons-per-year capacity each, were responsible for 60% of 1972 U.S. capacity, and would be classified as large producers of sodium sulfate. Fifteen plants, of 25,000 tons-per-year capacity or less, accounted for 12% of 1972 U.S. capacity, and would be classified as small. The remaining ten plants, with capacities between 25,000 and 100,000 tons per year each, accounted for 28% of 1972 U.S. capacity.

The base materials from which sodium sulfate is produced as a by-product are long-established chemical commodities. It is therefore not surprising that many of the plants producing sodium sulfate are fairly old. Most plants have been operating at least ten years; some nearly twenty years.

c. Manufacturing Economics

Raw materials for sodium sulfate production are either natural brines and salt deposits or sodium alkalis and sulfuric acid. In either case, nearly all of the manufacturing cost is represented by separation, drying, and packaging costs. In the case of natural sources, depletion costs must be covered; where sodium sulfate is formed as a joint product of some manufacturing process, raw material costs are often allocated to each product according to its relative value.

We understand that water pollution abatement costs have been developed only for chrome saltcake, i.e., that sodium sulfate produced as by-product from sodium bichromate manufacture. For that reason, our sodium sulfate manufacturing cost estimates are included with the sodium bichromate costs.

4. Supply/Demand Balance

Sodium sulfate has had an inverse relationship from that most often associated with the law of supply and demand. With nearly 90% of sodium sulfate production resulting from processes in which it is a by-product or co-product of some other material, and with both a low price and low profit margin, demand for this product has traditionally followed supply.

TABLE 16

SODIUM SULFATE PRODUCERS -- LOCATION AND CAPACITY

(Thousands of Tons)

Producer	Location	Annual Capacity	Process
Akzona Inc.			
American Enka Co., div.	Enka, N.C.	20	Polymer by-product
	Lowland, Tenn.	36	Polymer by-product
Allied Chem. Corp.			
Industrial Chems. Div.	Baltimore, Md.	50	Bichromate by-product
American Cyanamide Co.			
Indust. Chems. & Plastics Div.	Ft. Worth, Tex.	13	Catalyst by-product
IRC Fibers Co., subsid.	Painesville, Ohio	33	Polymer by-product
Chem. Met Corp.	Chicago, Ill.	--	
Climax Chem. Co.	Monument, N.M.	36	Mannheim furnace (HCl by-product)
Courtaulds North America, Inc.	Le Moyne, Ala.	25	Polymer by-product
El Paso Natural Gas Co.			
Beaunit Corp, subsid.			
Beaunit Fibers Div.	Elizabethton, Tenn.	25	Polymer by-product
FMC Corp.			
American Viscose Div.	Fredricksburg, Va. Fort Royal, Va. Lewistown, Pa. Marcus Hook, Pa. Nitro, W. Va. Parkersburg, W.Va.	275	Polymer by-product
Great Salt Lake Minerals & Chems. Corp.	Ogden, Utah	150	Natural; co-product
Green Bay Packaging, Inc.	Green Bay, Wisc.	--	By-product

TABLE 16 (Continued)

Producer	Location	Annual Capacity	Process
Gulf Resources & Chem. Corp. Lithium Corp. of America - Inc.,subsid.	Bessemer City, N.C.	18	By-product
Hercules, Inc. Coatings & Specialty Products Dept.	Glens Falls, N.Y. Hopewell, Va.	20	Bichromate by-product Polymer by-product
Kerr-McGee Corp. Kerr-McGee Chem. Corp. subsid.	Trona, Calif.	250	Natural, co-product
Koppers Co., Inc. Organic Materials Div.	Petrolia, Pa	15	Resorcinol by-product
Morton-Norwich Products, Inc. Morton Chem. Co. div.	Weeks Island, La.	120	Hargreaves furnace (HCl by-product)
Nalco Chem. Co. Industrial Div.	Chicago, Ill.	10	By-product
Ozark-Mahoning Co.	Brownfield, Tex. Seagraves, Tex.	185	Natural, sole product Natural, sole product
Pratt Sodium Co.	Casper, Wyo.	2	Natural, by-product
Reichhold Chems., Inc.	Tuscaloosa, Ala.	--	Phenol by-product
Stauffer Chem. Co. Indust. Chem. Div.	San Francisco, Calif. West End, Calif.	228	Boric acid co-product Natural
U.S. Borax & Chem. Corp.	Boron, Calif. Wilmington, Calif.	44	Boric acid co-product Boric acid co-product
	Total:	1,555	

Sources: Trade journals, industry reports.

With this type of relationship, there is often a time lag between increased supply and the development of new applications for the product. While supply often exceeds demand, the reverse is rarely true.

Evidence of this relationship of demand following supply is seen in the use pattern of sodium sulfate. From a technological point of view, very few uses of sodium sulfate result from unique chemical or physical properties of the compound. Rather, because of its relatively low price, sodium sulfate is often used wherever its chemical or physical properties allow its substitution in place of a more expensive material.

Substitution of sodium sulfate for higher cost materials wherever possible is a healthy economic practice, and does not detract from the importance of this chemical to both manufacturers and consumers. Even so, an excess of supply over demand is likely in the future, as water pollution abatement guidelines become more stringent. More rigorous water quality standards will have a dual effect: increasing recovery of by-product sodium sulfate, and decreasing consumption of sodium sulfate by kraft pulping mills and detergent manufacturers. Rayon and cellophane manufacturers, for example, currently recover only about one-third of the sodium sulfate produced by the industry. Kraft pulping mills, on the other hand, experienced sodium sulfate "losses" (in plant effluent) of about 250 pounds per ton of pulp in 1950, had reduced these losses to approximately 100 pounds per ton by 1972, and may be forced to reduce these losses by an additional 50% in the next decade. This lower demand as a result of kraft pulping effluent guidelines is in addition to reduced demand due to technical changes in bleaching and pulping operations.

In view of the joint-product nature of most U.S. sodium sulfate production, capacity figures are less meaningful for this chemical than for most others. Reported capacity is often much lower than theoretical capacity, and depends on the degree of commitment to recovering the sodium sulfate produced. Nevertheless, in terms of reported capacity, production of sodium sulfate has varied from 75% of capacity in 1964, to 100% in 1968. Production in 1972 represented approximately 90% of reported capacity.

On a regional basis, the U.S. south, northcentral, and northeast are net consumers of sodium sulfate, while the west and northwest are net producers. European sources supplement supplies to the U.S. south, and Canadian sources provide additional sodium sulfate to northern U.S. markets.

5. Prices

Published and actual prices of sodium sulfate for representative years since 1950 are given in Table 17. The published price for lower purity sodium sulfate (saltcake) has been $28 per ton since 1955. Actual prices for this grade have varied erratically in a narrow range from $20 to $22 per ton, indicating an average discount of 25%.

TABLE 17

SODIUM SULFATE PRICES -- PUBLISHED VS. ACTUAL

(Dollars per Short Ton)

Year	Published Price[1]		Actual Price[2]	
	Lower Purity	High Purity	Lower Purity	High Purity
1950	22	40	12	17
1955	28	52	22	27
1960	28	54	22	29
1965	28	56	21	27
1970	28	48	20	21
1971	28	43	21	20
1972	28	--	--	--

[1] Published prices bulk, works, 100% Na_2SO_4 basis for lower purity; bags, carlots, delivered East for high purity Na_2SO_4.

[2] Actual price: Value of Shipments/tons shipped.

Sources: Chemical Marketing Reporter, U.S. Department of Commerce, and Contractor's estimates.

Prices for higher grades of sodium sulfate are more difficult to characterize due to the number of different grades in this category, but it appears that considerable discounting occurs, and that the average price commanded by higher grades has declined in recent years. In 1971, the average price of high-purity sodium sulfate was below that of the lower quality grade. This unusual situation is most likely the result of increased recovery of this high-purity grade from rayon manufacture.

C. TITANIUM DIOXIDE

1. Summary

In 1972, U.S. titanium dioxide (TiO_2) consumption, including imports, was approximately 787,000 tons, with paint, paper and plastics applications accounting for nearly 80% of the total. Market demand growth in recent years has been at a 3% to 4% rate and is expected to continue at least at that rate through 1975. Imports remain a relatively small proportion (10%) of sales and are generally used only in non-critical, lower-cost applications.

While TiO_2 is sold in volumes comparable to those of some commodities, it is marketed more as a specialty chemical rather than a commodity. Producers' marketing efforts in recent years have been centered around grade improvement, quality control, and customer-oriented technical service. Depending on particular product expertise, individual producers frequently are strong in one market segment, such as paper, but do not fare as well in another--paint, for instance.

Current list prices are 28.5¢ per pound for rutile grades, 24¢ per pound for paper grade, and, at these prices, TiO_2 frequently is one of the more expensive raw materials in its end-use application. List prices have historically been stable or slowly rising, with the industry generally attempting to move as a whole to a given new price level. A long-established 1¢ per pound price differential between anatase and rutile grades disappeared in 1971 and both grades are currently offered at the same list price. Due mostly to overcapacity problems, the industry has been plagued with substantial price discounts which forced several major producers to operate at a loss in the 1970-71 period. Prices have firmed in recent months.

TiO_2 is manufactured by either of two processes--sulfate and chloride. Current domestic manufacturing capacity is about 817,000 tons, approximately 54% of which is sulfate. The sulfate process is older and employs sulfuric acid to separate and recover TiO_2 from ilmenite, the principal raw material used in this manufacturing route. The sulfate process has the disadvantage of producing a large amount of potential pollutants in the form of spent sulfuric acid and ferrous sulfates (copperas). Depending on processing steps employed, both anatase and rutile, the two chemical forms of TiO_2, can be produced. Estimated current manufacturing cost for pigment via the sulfate process is approximately 21¢ per pound, including pigment finishing steps.

The alternate method of production, and the one employed in every TiO_2 plant built since 1956, is the chloride process. In this process, chlorine is reacted at high temperature with the raw ore, generally rutile, a high TiO_2-content material. TiO_2 is recovered later in the process through further chemical treatment, and approximately 90% of the chlorine is recovered for reuse. Due to higher quality ore and reactant recycling, the chloride process produces far less pollutant by-product than the sulfate process. Although rutile pigment has been the sole product from the chloride process in the past, Du Pont will begin production of both anatase and rutile grades upon conversion of its Edgemoor, Delaware, plant to 100% chloride production in 1974. Chloride pigment has more uniformly consistent particle size, hence it offers greater hiding power and is used preferentially in certain critical applications such as automotive paint. Current chloride process manufacturing cost is estimated at nearly 23¢ per pound.

TiO_2 for commercial production is obtained from four principal sources--ilmenite, rutile, leucoxene, and slag. Ilmenite contains approximately 50% TiO_2, is mined virtually worldwide, and is the basic raw material for the sulfate process and for Du Pont's chloride process plants. World supply is plentiful with present production of nearly three million short tons per year. U.S. production is approximately 700,000 short tons. Rutile, containing 95+% TiO_2, is the raw ore for most chloride production and is found almost exclusively in Australia. World supplies are believed to be limited to 20-25 years at present production rates of over 400,000 long tons per year. No rutile is mined in the U.S.

Leucoxene and titanium slag, used in sulfate production, are relatively minor sources of TiO_2 worldwide, although over 100,000 tons of Canadian slag are imported into the U.S. every year.

2. Market Characterization

a. Market Size and Growth

U.S. market demand for TiO_2 pigments in 1972 was approximately 787,000 short tons, valued at nearly $433 million on a delivered basis. Table 18 shows the recent history of TiO_2 production, trade and shipments data. Since 1965, overall market growth has been at an annual rate of 3% to 4%, although certain individual end-use segments, such as plastics, have grown considerably faster.

Exports of TiO_2 have remained quite small, less than 2% to 3% of domestic production, and have actually declined somewhat in recent years. Imports, on the other hand, have ranged in recent years from 5% to 10% of total apparent consumption, although 1972 saw a large jump to 86,400 tons, or 11% of apparent consumption. Imports will probably continue at present percentage levels for the foreseeable future.

b. Product Uses

Table 19 identifies the major end uses and recent consumption history for TiO_2 pigments. Paint and coatings applications, currently

TABLE 18

TiO_2 APPARENT CONSUMPTION AND INDUSTRY SHIPMENTS

(Thousands of Tons)

Year	Production	Imports	Exports	Stocks	Apparent Consumption	Total Shipments	Commercial Shipments
1965	576.7	49.6	17.0	101.7	606.3	573.0	524.5
1966	594.5	48.0	15.0	98.5	630.7	593.3	545.4
1967	589.4	46.8	14.0	103.3	617.4	582.3	542.5
1968	623.7	53.3	15.0	94.2	671.1	632.1	564.4
1969	664.3	53.2	14.0	100.8	684.3	654.5	590.1
1970	655.3	60.2	15.0	106.9	691.4	643.7	560.9
1971	677.8	42.8	14.0	89.7	723.6	684.7	581.2
1972	687.3	86.4	10.0	66.3	787.1	-----	-----

Sources: U.S. Department of Commerce "Current Industrial Reports" and Tariff Commission trade data.

TABLE 19

TiO_2 MARKET CONSUMPTION
(Thousands of Tons)

	1965	1970	1972
Paint and Coatings	345	375	390
Paper	110	147	158
Plastics	27	59	78
Rubber	31	35	35
Floor Covering	29	30	30
Printing Ink	12	18	20
Ceramics	10	17	21
Synthetic Fibers	6	10	10
Roofing Granules	4	5	5
Other	26	34	40
Total	600	730	787

Source: Contractor's estimates.

accounting for 50% of total consumption, constitute the major use for TiO_2. Two other end uses, paper and plastics, have grown rapidly in recent years, and in 1972, accounted for an additional 30% of TiO_2 consumption.

(1) Paint and Coatings

The paint and coatings industry is comprised of two basic segments--trade and industrial--with trade sales accounting for about 60% or 235,000 tons of TiO_2 consumption in the paint industry. Due to its interior hiding power and dispersibility (relative to rutile), anatase grade TiO_2 is rarely used, exceptions being low-cost applications such as highway paint. Within rutile grades, chloride process pigments account for about 60%, or 240,000 tons of paint pigment.

Sulfate producers have worked hard in recent years to eliminate previous performance deficiencies of sulfate rutile grades, and for many trade sales applications, such as interior wall paint and exterior house paint, sulfate and chloride grades are interchangeable. In industrial applications, the chloride process pigments, with Du Pont's R-900 series grades as the industry standards, enjoy clear superiority.

A critical factor in selling TiO_2 to the paint industry is a customer-oriented marketing effort. With TiO_2 pigment cost typically comprising 10% to 25% of paint selling price, paint manufacturers demand quality technical service and grade development to meet ongoing paint application needs. Imported TiO_2 has fared poorly in the paint industry due to lack of good customer service.

(2) Paper

1972 TiO_2 sales to the paper industry were about 158,000 tons and sales to the industry have been growing at 6% per year. Anatase grade pigments, because of their lower cost, account for about 70%, or 110,000 tons, of pigment sales. (TiO_2 frequently competes with 10 to 12¢ per pound clays for whitening and opacity filler applications; hence cost is a critical factor, and imported anatase grades have made their most successful penetration in this market.)

There are two main application areas within the paper industry--beater and coatings. Beater applications call for pigment addition directly to the paper pulp, and there is much grade and supplier interchangeability. A recent trend in beater use has been an increased TiO_2 requirement as paper sheet has become thinner while retaining opacity. In the coating area, use of rutile grade TiO_2 has been increasing, and there is less grade interchangeability than in beater use.

(3) Plastics

The fastest growing market segment for TiO_2 is plastics, with 1972 consumption of about 78,000 tons and a recent growth rate of nearly

17% a year. Major application areas included polyethylene injection molding and film production, polystyrene extrusions, and vinyl extrusions, such as outdoor siding and moldings. Product performance is the critical factor in plastics use, and rutile accounts for over 95% of TiO_2 sales. Rutile pigment, both chloride and sulfate, is superior to anatase in dispersion and resistance to discoloration and weathering. Technical service is very important, and it is common for producer and user to work together in developing new applications. Imported TiO_2, again due to lack of customer service, has made little headway in this market.

(4) Other Applications

The remaining applications shown in Table 19 make up the remaining 161,000 tons of TiO_2 consumed in 1972. Individual applications and their consumption relative to the total are as follows: rubber, 4%; floor covering, 4%; printing ink, 2.6%; ceramics, 2.6%; synthetic fibers, 1%; roofing granules, 0.5%.

c. Substitute Products

TiO_2 use presently is threatened by substitute products in only one market segment, paper. There TiO_2 enjoys the advantage of being an effective opacifier, but it is at a cost disadvantage to alumina and silica clays, some of which offer nearly equivalent brightness as TiO_2. In the paint industry, TiO_2 is by far the most effective white pigment in terms of hiding power, a key to the trend toward one-coat paint applications. While pigment research is extensive, no equally effective substitute has been found. In plastics and rubber, TiO_2 offers the best combination of white pigment cost, dispersion, and resistance to discoloration. In other product application areas, no substitute products represent serious threats to TiO_2's present position.

d. Captive Consumption

The major captive use of TiO_2 pigment is in the paint industry, where three of the top six TiO_2 consumers have their own pigment plants. Table 20 details captive TiO_2 consumption and shows the rise in captive use as a percentage of apparent consumption from 8% in 1965 to 14% in 1971. Sherwin-Williams, Du Pont, Glidden-Durkee, and NL Industries are the major captive users, and it is believed that these companies account for virtually all of the captively-consumed TiO_2 pigment.

3. Supply

a. Manufacturing Processes

Two commercial processes are presently employed to produce TiO_2 pigments--the sulfate process and the chloride process. The sulfate process is older and is the process employed by most of the existing worldwide

TABLE 20

TiO_2 CAPTIVE CONSUMPTION

(Thousands of Tons)

Year	Total Shipments	Commercial Shipments	Captive Consumption[1]	Percent Apparent Consumption
1965	573.0	524.5	48.5	8.0
1966	593.3	545.5	47.8	7.6
1967	582.3	547.5	39.8	6.4
1968	632.1	564.4	67.7	10.1
1969	654.5	590.1	64.4	9.4
1970	643.7	560.9	82.8	12.0
1971	684.7	581.2	103.5	14.3

[1] Captive consumption is calculated as total shipments - commercial shipments.

Source: Current Industrial Reports, U.S. Department of Commerce.

capacity. The chloride process was developed in the 1950's and is used in all new TiO_2 plants built in the U.S. since 1956. In recent years chloride process plants have become increasingly widespread in Europe as well.

(1) Sulfate Process

Figure 7 left-hand side, is a schematic representation of the sulfate process. In the first step ilmenite, an ore or sand containing 40-60% TiO_2, or titanium slag, containing 60-70% TiO_2, is digested with sulfuric acid. The amount of acid required ranges from 2.5 to 4.5 pounds per pound of finished pigment and depends on the TiO_2 content of the ore. In addition to the formation of titanium sulfate salts, substantial amounts of ferrous sulfate are also formed since the other major component of ilmenite is iron oxide, FeO. The remainder of the process involves separating the various sulfate salts, with iron being removed from the process as hydrated ferrous sulfate, copperas, and TiO_2 being precipitated in the hydrolysis step. This final chemical form of the TiO_2 pigment, anatase or rutile, is determined by the nucleus crystal used to seed precipitation in this step. The TiO_2 precipitate is next calcined at temperatures of up to 1250° C, during which adsorbed sulfur trioxide and water are driven off and, if rutile seeds were used in the hydrolysis step, rutile-type pigment is formed. The pigment finishing process will be described later.

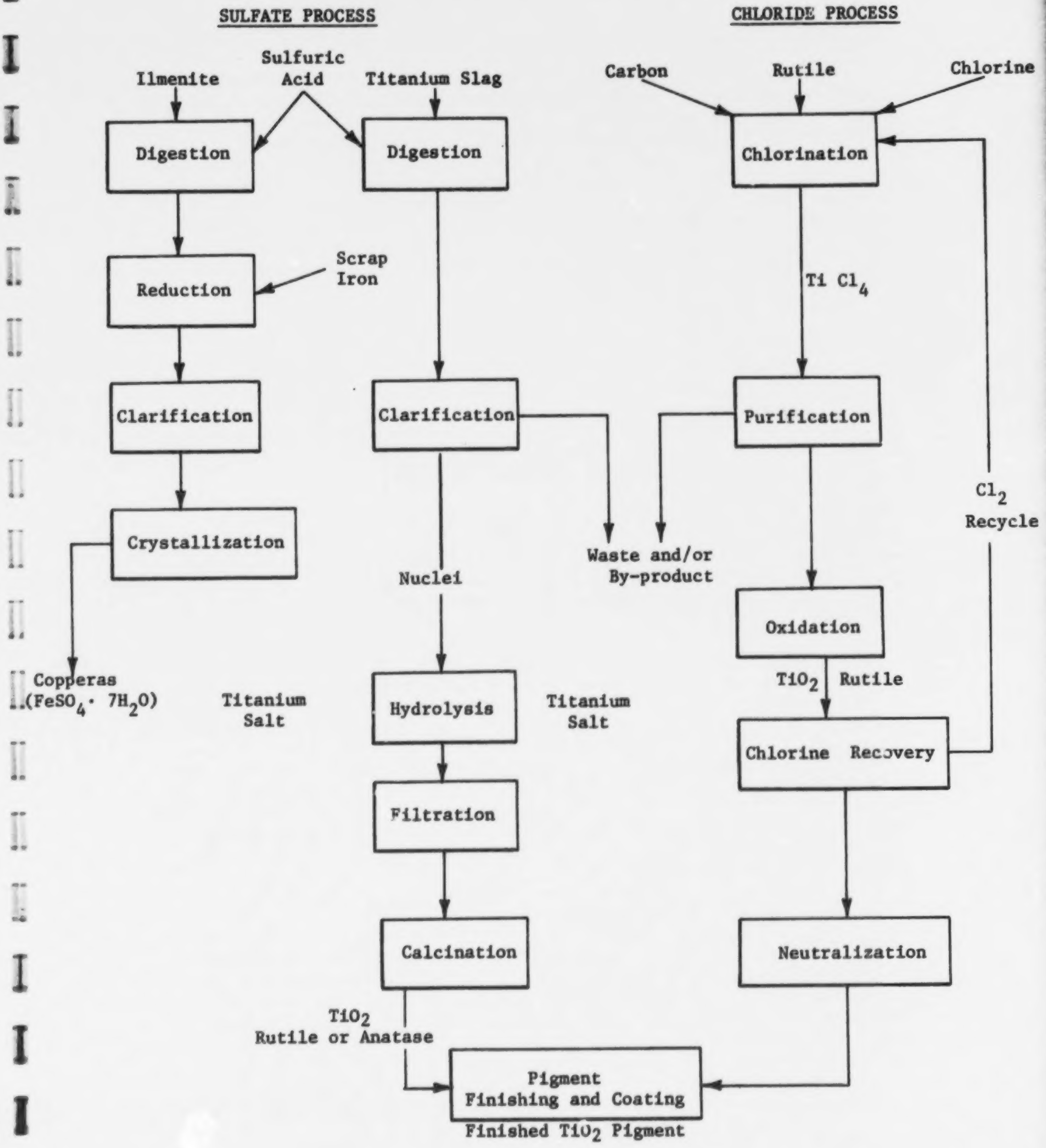
(2) Chloride Process

The chloride process typically utilizes rutile ore containing 90% to 97% TiO_2 as its raw material. Du Pont has developed the capability to use ilmenite, thereby lowering its raw material costs significantly. Figure 7 right-hand side, outlines the process. In the first step, rutile ore is burned with chlorine gas to produce titanium tetrachloride. This material is separated from the reaction mixture via distillation, then is oxidized at high temperature to produce TiO_2 particles, which are quickly quenched. The quenching process allows extremely close control of pigment particle size which is essential in developing hiding power of the pigment. Chlorine is recovered in the oxidation process and is recycled for use in the first step. As in the sulfate process, the refined TiO_2 pigment is sent to finishing steps which enhance the surface properties of the pigment particles.

Although the chloride process is conceptually straightforward and does not produce the substantial quantities of waste materials that the sulfate process does, it has been extremely difficult to operate commercially. One problem has been the extreme corrosiveness of the high temperature chlorine employed. A second, more fundamental problem, has been the oxidation step, which is extremely sensitive to burner configuration and to product recovery methods. Du Pont is the most successful in this regard and holds significant patent protection in this technology.

FIGURE 7

TiO_2 PIGMENT MANUFACTURING PROCESSES


SULFATE PROCESS
CHLORIDE PROCESS
Ilmenite
Sulfuric Acid
Titanium Slag
Digestion
Digestion
Reduction
Scrap Iron
Clarification
Clarification
Crystallization
Copperas ($FeSO_4 \cdot 7H_2O$)
Titanium Salt
Nuclei
Hydrolysis
Titanium Salt
Filtration
Calcination
TiO_2 Rutile or Anatase
Waste and/or By-product
Carbon
Rutile
Chlorine
Chlorination
Ti Cl_4
Purification
Cl_2 Recycle
Oxidation
TiO_2 Rutile
Chlorine Recovery
Neutralization
Pigment Finishing and Coating
Finished TiO_2 Pigment

(3) Pigment Finishing

Before pigment from either process is sold, it is processed through a series of finishing operations in which specific particle surface properties are developed. These properties in turn determine characteristics such as pigment dispersibility and durability. For instance, pigment intended for plastics use is usually treated with an organic agent, dimethyl siloxane, to enhance the pigment's compatibility with the plastic system. Sulfate producers have made their pigments more competitive with chloride pigments in recent years through careful control of particle size and coating characteristics obtained in finishing operations. Such finishing steps generally add 1-2¢ to the basic manufacturing cost of the pigment.

b. Producers

At the end of 1972, there were 11 domestic TiO_2 producers operating 15 plants, all but one of which are in the eastern half of the U.S. Table 21 summarizes pertinent information regarding these facilities. Since 1956, chloride process facilities have accounted for all new TiO_2 pigment plant construction. Possibly reflecting producer's uncertainty about process technology and economics, individual capacity of most chloride plants is in the 25,000 to 30,000 ton range. The notable exception is Du Pont, which is increasing the capacity of their New Johnsonville, Tennessee, plant to 195,000 tons by year-end 1973 and is actively considering a new 100,000 ton chloride facility in Georgia. Two producers, PPG and NL Industries, have recently closed their chloride facilities, moves reportedly due to raw material supply and economics problems.

Several of the large producers--Du Pont, NL Industries, and Glidden-Durkee--have integrated their operations backward to provide captive supplies of ilmenite ore. (No domestic producer has a captive source of rutile as virtually all of this raw material is imported from Australian producers.) These three producers have also achieved forward integration through captive TiO_2 supply for their paint products. No other domestic producers have achieved integration to a comparable extent. Most TiO_2 plants are isolated manufacturing facilities, although a few are part of larger, multi-product facilities, and most plants produce and sell titanate and other salts as by-products from the process.

c. Manufacturing Economics

Tables 22 and 23 summarize estimated manufacturing economics and profitability for a 25,000 ton sulfate plant. The costs for raw materials, utilities, direct labor, and overhead, are based on current estimates for these items. For the sulfate process, two investment bases are used--replacement and depreciable. The replacement basis is an ADL estimate of current plant replacement cost and is used for calculation of insurance and maintenance, since these items are best reflected by current costs and replacement value. A depreciable basis

TABLE 21

TiO_2 MANUFACTURING LOCATIONS AND CAPACITIES

(Thousands of Tons)

Company	Location	Annual Capacity	Process[4]	Raw Material	Start-Up Year
American Cyanamid	Savannah, Ga.	70	S	Imported ilmenite, slag	1955
		40	C	Imported rutile	1966
		110			
Cabot	Ashtabula, Ohio[5]	27	C	Imported rutile	1964
Combustion Engineering	Camden, N.J.	n.a.	→		
	Wilmington, Del.	n.a.	→		
E.I. Du Pont	Antioch, Cal.	27	C	Imported rutile	1963
	Edgemoor, Del.[1]	100	S	Captive ilmenite, slag	1935
			C	Captive mixture of ilmenite/ leucoxene, imported rutile	1956
	New Johnsonville, Tenn.[2]	141	C	Captive mixture of ilmenite/ leucoxene, imported rutile	1959
		268			
N.J. Zinc (Div. of G&W)	Gloucester City, N.J.	42	S	Slag	1946
Kerr-McGee	Hamilton, Miss.	45	C	Imported rutile	1965
Lonza	Mapleton, Ill.	n.a.	→		
N.L. Industries	St. Louis, Mo.	108	S	Captive ilmenite	1923
	Sayreville, N.J.[3]	115	S	Captive ilmenite	1918
			C	Imported rutile	1966
		223			
Glidden-Durkee (Div. of SCM)	Baltimore, Md.	50	S	Captive ilmenite, slag	1956
		25	C	Imported rutile	1970
		75			
Sherwin-Williams	Ashtabula, Ohio	27	C	Imported rutile	1969
Transelco	Penn Yan, N.Y.	n.a.	→		
		817			

[1] Converting to all-chloride process and expanding to 112,000 tons by year end 1973.

[2] Expanding to 195,000 tons by year end 1973.

[3] Announced closing January 1973.

[4] S = Sulfate; C = Chloride.

[5] Plant being operated by N.J. Zinc (Div. of G&W) under lease-purchase agreement.

Sources: Chemical Economics Handbook and Contractor's estimates.

TABLE 22

TiO_2 MANUFACTURING ECONOMICS--SULFATE PROCESS

Basis: Sulfate Process
25,000 T/Yr, 100% of Capacity
330 Days/Yr
Replacement Investment--$26,325,000[1,3]
Depreciable Investment--$15,000,000

Item	Unit	$/Unit	Units/Ton	$/Ton Pigment
Raw Materials				
Ilmenite (56% TiO_2)	Ton	21.00	1.87	39.27
Sulfur	Ton	30.00	0.88	26.40
Caustic	Ton	55.00	0.20	11.00
Other Chemicals	---		----	30.00
				106.27
Utilities[2]				
Water	MGal	0.10	220	22.00
Electricity	kwh	0.014	525	7.35
Natural Gas	MMBtu	0.60	10	6.00
				35.35
Direct Labor[2,4]				
Supervision	Man Hr	7.50	1.58	11.85
Operators	Man Hr	5.00	4.43	22.15
Helpers	Man Hr	4.00	3.80	15.20
				49.20
Overhead				
@ 100% Direct Labor		----	----	49.20
Maintenance, Labor, and Supplies				
@ 7% of Replacement Investment/Yr				73.71
Depreciation				
@ 9.1% of Depreciable Investment/Yr				54.60
Insurance and Local Taxes				
@ 2.0% of Replacement Investment/Yr				21.06
Total Manufacturing Cost Per Ton				$389.39
Manufacturing Cost Per Lb. Pigment				$ 0.195

[1] Capital investment based on Contractor's estimates.
[2] Assumes wage rates and utilities rates of New Jersey area.
[3] Assumes capital cost of H_2SO_4 plant included. Does not include solid waste handling capital or operating costs.
[4] See labor schedule included.

Source: Contractor's estimates.

TABLE 22 (Continued)

LABOR SCHEDULE
TiO_2 PRODUCTION--SULFATE PROCESS

	Supervisors	Operators	Helpers
Feed Preparation Section	1	1	2
Digestion and Separation Section		4	3
Hydrolysis--Precipitation Section	1	3	2
Purification Section	1	1	1
Calcination--Dry Milling Section	1	1	1
After Treatment Section	1	3	3
Sulfuric Acid Plant	___	1	___
Total--Men/Shift	5	14	12

TABLE 23

TiO_2 PIGMENT PROFITABILITY--SULFATE PROCESS

Investment: $15,000,000
Manufacturing Cost: $0.195

	(Rutile Grade)	(70/30 Rutile/Anatase Mix)	(Anatase Paper Grade)
Pigment Selling Price	$0.275/Lb.	$0.26/Lb.	$0.24/Lb.
Gross Profit/Lb.	0.080	0.065	0.045
Gross Profit/Ton	160.00	130.00	90.00
Freight at 5% of List Price Sales/Ton	27.50	27.50	27.50
General, Selling, & Administrative @ 7.5% of List Price Sales/Ton	41.25	41.25	41.25
Profit Before Taxes/Ton	91.25	61.25	21.25
Profit After Taxes/Ton	46.62	30.62	10.62
Profit After Taxes as % of Sales	8.3	5.9	2.2
	CASH FLOW		
Profit After Taxes/Ton	46.62	30.62	10.62
Plus Depreciation/Ton	54.60	54.60	54.60
Total Cash Flow/Ton	101.22	85.22	65.22
Total Cash Flow @ 25,000 Tons	2,540,000	2,130,000	1,630,000
Investment	15,000,000	→	→
Working Capital (3 months' operating costs)	2,433,000	→	→
	17,433,687	→	→
Payback (Yrs)	6.9	8.2	10.7
% Return on Capital Employed	15.0	12.0	9.3

Source: Contractor's estimates.

of smaller dollar size than replacement value is used for depreciation since most sulfate plants are 20 to 30 years old, and current depreciable assets are restricted to recently replaced process equipment and newly installed finishing equipment. A depreciation rate of 9.1% per year is used as this rate is the highest allowed by the Internal Revenue Service for chemical industry facilities. Since all TiO_2 grades are sold on a delivered basis, a freight charge of 5% of list price has been included in Table 23. General selling and administrative charges of 7.5% of list price sales reflect the relatively expensive selling effort required for TiO_2 pigments.

Table 23 shows that depending on grade and price, after tax profitability ranges from 7.1% down to 2.2% of sales. In addition, return on capital could theoretically be as high as 13.7% after tax, although 11.5%, based on a product mix of 70:30 rutile/anatase grades, is probably more representative of actual industry performances.

Tables 23 and 24 detail similar costs and profitability figures for a 25,000-ton chlorine plant. The depreciable and replacement investment basis are considered the same in this case since most chloride plants not only are relatively new with substantial original book value remaining, but also have experienced the updating of process and finishing equipment found in sulfate process plants. As seen in Table 25, while the after-tax profit percentage is low, 3.6%, the return on capital, at 10.2%, is considerably higher. By virtue of a large depreciation tax shield, the chloride process apparently generates substantial cash flow, despite low-book profits. It should be noted that chloride profit margins have shrunk recently, largely due to the dramatic rise in rutile ore prices, now $175 per ton and higher. Ore cost comprises over 50% of the cost of manufacture, and this item has been most responsible for the elimination of the chloride process' earlier cost advantage over the sulfate process. Chloride pigment producers are anxious to see this cost drop through either more widespread use of ilmenite or through successful commercialization of synthetic rutile production. An important factor in economical chloride production is recovery and recycle of chlorine gas after the oxidation step. The highly corrosive nature of chlorine makes this step difficult, but failure to do so can result in extraordinarily high use of makeup chlorine.

d. Raw Materials

Ready availability of inexpensive raw materials is one of the key requirements for the continued production of low-cost TiO_2 pigments. Economic production via the chloride process has been seriously threatened by the recent, dramatic increase in rutile ore prices. In contrast, ilmenite prices have risen only slightly to $35 per ton. The reason for these different behaviors is the supply/demand balance for each ore.

Ilmenite is mined virtually worldwide, with 1971 world production being almost 2.9 million short tons. U.S. ilmenite production has declined from 930,000 tons in 1969 to 680,000 tons in 1971, but worldwide

TABLE 24

TiO_2 MANUFACTURING ECONOMICS--CHLORIDE PROCESS

Basis: Chloride Process
25,000 T/Yr, 100% of Capacity
330 Days/Yr
Investment (Depreciable and Replacement)--$21,330,000[1]

Item	Unit	$/Unit	Units/Ton	$/Ton Pigment
Raw Materials				
Rutile	Ton	175.00	1.17	204.75
Coke	Ton	24.00	0.35	8.40
Chlorine	Ton	50.00	0.21	10.50
Chemical Additives	---	-----	----	7.00
				230.65
Utilities[2]				
Water	MGal	0.10	23	2.30
Electricity	kwh	0.014	750	10.50
Natural Gas	MMBtu	0.60	10	6.00
Refrigeration	Ton/Day	3.00	2.5	7.50
				26.30
Direct Labor[3]				
Supervision	Man Hr	7.50	0.95	7.12
Operators	Man Hr	5.00	5.4	27.00
				34.12
Overhead				
@ 100% Direct Labor				34.12
Maintenance, Labor, and Supplies				
@ 6% of Investment/Yr				51.19
Depreciation				
@ 9.1% of Investment/Yr				77.63
Insurance and Local Taxes				
@ 2% of Replacement Investment/Yr				17.06
Total Manufacturing Cost Per Ton				$454.01
Manufacturing Cost/Lb Pigment				$ 0.227

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[1] Capital Investment based on Contractor's estimates.
[2] Assumes wage and utilities rates of New Jersey.
[3] See labor schedule included.

TABLE 24 (Continued)

LABOR SCHEDULE
TiO_2 PRODUCTION--CHLORIDE PROCESS

Operators	Men/Shift
Load in	1
Chlorination reactor	1
Quench, $TiCl_4$ recycle, storage	1
Sludge filter, waste	1
$TiCl_4$ purification	2
$TiCl_4$ vaporizer, preheat, additives	1
Oxidation chamber	1
$TiCl_4$ quench, cyclones, bag filter	1
Chlorine recovery	1
After treatment	4
Bagging, warehouse	2
Oxygen plant	1
Total	17

Supervisors	
Chlorination, purification	1
Oxidation	1
After treatment	1
Total	3

TABLE 25

TiO_2 PIGMENT PROFITABILITY--CHLORIDE PROCESS

Investment: $21,330,000
Manufacturing Cost: $0.227/Lb.

Pigment Selling Price	(Rutile Grade) $0.275/Lb.
Gross Profit/Lb.	0.048
Gross Profit/Ton	96.00
Freight at 5% of List Price Sales/Ton	27.50
General, Selling, & Administrative @ 7.5% of List Price Sales/Ton	41.25
Profit Before Taxes/Ton	27.25
Profit After Taxes/Ton	13.625
Profit After Taxes as % of Sales	2.5

CASH FLOW

Profit After Taxes/Ton	13.62
Plus Depreciation/Ton	77.63
Total Cash Flow/Ton	91.25
Total Cash Flow @ 25,000 Tons	2,281,375
Investment	21,330,000
Working Capital (3 months' operating costs)	2,837,500
	24,167,500
Payback (Yrs)	10.6
% Return on Capital Employed	11.7

supply has been filled by increased production in Australia and Norway. Present reserves of ilmenite are such that, at the present annual world consumption rate of nearly three million tons, adequate supplies of sufficient quality ore should be available for nearly 100 years.

The rutile ore supply situation, however, is not so bright. Rutile production in recent years has remained constant at slightly over 400,000 tons and is confined almost exclusively to the east coast of Australia. Significant deposits are believed available in Sierra Leone, but technical problems have hampered attempts to exploit this source. There is no rutile ore mined in the U.S. A large increase in worldwide chloride pigment process capacity has greatly increased demand, and present rutile reserves are estimated to be barely 20 years. These conditions have fostered a rise in rutile ore price from $100 per ton in 1965 to $180 per ton presently.

A major hope in the bleak rutile supply situation is the commercialization of synthetic rutile production. This process involves chemical leaching of ilmenite ore to remove iron impurities and to upgrade the TiO_2 content to approximately 90%. Since nearly two tons of ilmenite are required to produce one ton of synthetic rutile, waste disposal considerations will adversely affect the rapid development of domestically available synthetic rutile, although both Sherwin-Williams and Kerr McGee are actively pursuing this technology. Semi-commercial synthetic plants are in operation in Australia and Japan, and the product has been tested and found acceptable in most U.S. chloride process pigment plants. Chloride producers anticipate that synthetic rutile will begin to appear commercially by 1975 at $130-150 per ton and feel that this material will be significant in keeping chloride pigment production economically viable.

The other significant factor in chloride process raw materials has been the development of Du Pont's ability to utilize ilmenite ore in its chloride plants. Although this capability has always been technically feasible, it has been uneconomic due to the high chlorine loss resulting from chlorinating the 40% of iron oxide present in ilmenite. Du Pont, however, has developed the ability to minimize chlorine use and is able to produce chloride pigment for an estimated 1-2¢ per pound less than rutile-based chloride processes. Since ilmenite is much more widely available than rutile, other chloride producers are working on both ilmenite beneficiation technology and direct ilmenite use capability in chloride processing. Thus far, however, Du Pont remains the only producer using ilmenite directly.

The last major source of TiO_2 is titanium slag, which is produced in Canada from plentiful, low-quality ilmenite ores. The ilmenite used here is closely intermixed with iron ores, and smelting is employed to produce pig iron and titanium slag containing 70% to 72% TiO_2. Slag cannot be used in the chloride process due to the formation of insoluble chloride salts which plug up processing equipment. While other raw materials such as chlorine, coke, and sulfuric acid are used in

TiO_2 pigment production, these items are widely available and do not constrain the production process to the degree that TiO_2 ores do.

4. Supply/Demand Balance; Prices

Industry capacity has been sufficient to supply demand as almost continual additions to capacity have been made. Table 26 summarizes capacity and production figures for recent years and shows that capacity utilization has been in the 75% to 85% range. Capacity has been taken at announced, or nameplate, levels and is higher than effective capacity due to grade/product mix constraints. The industry is now facing a tight-supply situation with NL Industries announcing the closing of its chloride facilities in Sayreville, New Jersey. Du Pont's announced expansions won't be operational until year-end 1973.

This supply situation is substantially different from that of 1970-71 when over-supply forced a sharp depression in prices. Table 27 summarizes recent shipment valuation history and confirms industry claims that the 1970-71 period saw severe price competition, despite stable list prices. Demand and prices have improved with the economic recovery and recent list prices stand at: standard anatase and rutile grades, bulk--28.5¢ per pound; paper grade anatase--24¢ per pound. Most producers are running at full capacity presently, and shipments are being made at list prices.

TABLE 26

TiO_2 INDUSTRY PLANT CAPACITY UTILIZATION
(Thousands of Tons)

	Capacity	Production	Percent Utilization
1965	713	576.7	81
1966	725	594.5	82
1967	766	589.4	77
1968	746	623.7	84
1969	778	664.3	85
1970	817	655.3	81
1971	805	677.8	84
1972	817	687.3	84

Sources: Chemical Economics Handbook and Current Industrial Reports.

TABLE 27

TiO_2 COMMERCIAL SHIPMENT VALUES

(Shipments in Thousands of Tons)

	Commercial Shipments	Total Value[1]	Value/Lb.[2]	List Prices[3]	
				Anatase	Rutile
1965	524.5	274.7	.261	.25	.26
1966	545.4	279.7	.256	.25	.26
1967	542.6	277.2	.255	.25	.26
1968	564.4	288.8	.256	.25	.26
1969	590.1	301.1	.255	.26	.27
1970	560.9	277.8	.248	.26	.27
1971	581.2	262.4	.226	.26	.26

[1] Value in $ Millions.
[2] Value in $ per Pound.
[3] Carlot, $ per Pound.

Source: Current Industrial Reports, U.S. Department of Commerce.

D. SODIUM CHROMATE AND BICHROMATE

1. Summary

The U.S. sodium bichromate market has been characterized by essentially static demand during the past five years at approximately 150,000 tons annually. The market outlook for the next five years is for a slight overall contraction in demand with deteriorating markets in water treating and textiles (resulting from more stringent water quality standards) only partially offset by modest demand growth for chromic acid, chrome colors and catalyst applications. Very nearly half of current demand for sodium bichromate is for chrome colors and chromic acid. Other uses include leather tanning, metal treating, textiles, water treating and catalyst manufacture. Substitute products (or processes) exist for most bichromate derivatives, constraining demand growth.

There are currently three producers of sodium chromate and bichromate--Allied Chemical, Diamond Shamrock and PPG Industries. Aggregate captive requirements of these three companies approximate 35% of current production. U.S. producers of sodium bichromate are dependent on foreign sources, primarily the Republic of South Africa, for chromite ore, the basic raw material.

Manufacturing costs are estimated at $212 per ton. Assuming GS&A at 5.5% of sales and a weighted average selling price of $262 per ton (including some chrome salt cake by-product credit), the industry after-tax income in 1972 approximated $18.50 per ton, equivalent to a 7.1% return on sales.

During the period 1960-1971, actual prices (as calculated from Commerce Department data for dollar values and tonnages) received by the industry have remained in a remarkably narrow range between $240 and $255 per ton. Although confirming Commerce Department data are not yet available, list price increases made recently probably have been reflected in somewhat higher plant prices. These price increases are believed to have been made possible primarily as a result of a somewhat less aggressive posture by foreign production sources, notably Italy and Japan. Producers in both these countries are understood to be facing higher manufacturing costs as a result of more stringent water pollution abatement standards. Nonetheless, imports have exceeded exports in seven of the last ten years.

2. Market Characterization

In Table 28 is shown the apparent U.S. consumption of sodium chromate and bichromate for the period 1960 through 1972. For most of this period, U.S. production, as reported by the Department of Commerce, has varied between 135 and 155 thousand tons annually. As indicated, these data include both sodium chromate and sodium bichromate. While some of the sodium chromate produced in the initial phase of the manufacturing process is marketed as such (an estimated 15 thousand tons of bichromate equivalent), most of the sodium chromate filtrate is further processed to produce sodium bichromate.

Imports, primarily from the U.S.S.R. and Japan in 1972, have varied in the last several years between 3.5 and 6.5 thousand tons. The sharp drop in imports from 1966 to 1967 reflected decreased U.S. demand. As a result of the Kennedy round agreements, the import rate of duty was reduced to $0.87 per pound as of January 1, 1972.

Exports, primarily to Canada, have trailed imports in recent years. In 1972 exports totaled 4.03 thousand tons valued at $0.93 million. Canada received the bulk (70%) of 1972 exports, with Colombia next at very nearly 20%. For purposes of estimating apparent consumption, we have ignored changes in stocks of chromium chemicals at producer plants.

On a long-term basis (in the post-World War II period), apparent U.S. consumption of sodium chromate and sodium bichromate has increased at an average annual compound rate of 2.4% per year. In each of the last three years, however, consumption has declined; the outlook is for a continuation of the recent trend.

a. Uses

In Table 29 is shown the estimated 1971 use pattern for sodium chromate and bichromate. Very nearly 50% is consumed in the manufacture of chrome colors and chromic acid. In descending order of bichromate consumption, the most important chromate colors are chrome yellow and orange, chromium oxide green, molybdate orange, and zinc yellow and chrome green. Production of chromium pigments in 1971 and the estimated bichromate equivalent requirements is shown in Table 30. Requirements for U.S. sodium bichromate in pigment production would have been higher were it not for the substantial imports of chrome colors. Imports of chromium-containing pigments in 1971 included chromium yellow, 6.2 thousand tons; chromium oxide green, 0.9 thousand tons; chrome green, 0.3 thousand tons; zinc yellow 1.08 thousand tons; and molybdate orange, 0.3 thousand tons. Total value of these products and miscellaneous other chrome colors was $4.5 million, 17% higher than in 1970.

A major use for chrome yellow is the yellow center strip line for highways. Chromium oxide green is used where chemical and heat resistance is required, e.g., in ceramic colors, for coloring cement and in green asphalt roofing. Zinc yellow finds application as a corrosion inhibitor

TABLE 28

APPARENT U.S. CONSUMPTION OF SODIUM CHROMATE AND BICHROMATE

(Thousands of Short Tons, $Na_2Cr_2O_7 \cdot 2H_2O$)

Year	Production	Imports	Exports	Apparent Consumption
1960	121.9	1.9	9.6	114.2
1961	120.9	1.6	7.1	115.4
1962	127.5	2.5	5.0	125.0
1963	133.9	3.5	5.1	132.3
1964	137.9	3.4	6.7	134.6
1965	141.0	18.0	4.0	155.0
1966	141.5	24.1	2.6	163.0
1967	135.3	8.2	3.3	140.2
1968	146.0	11.6	4.8	152.8
1969	152.6	6.5	5.1	154.0
1970	153.5	3.6	4.9	152.2
1971	138.2	6.4	3.1	141.5
1972	137.1	5.7	4.0	138.8

Source: U.S. Department of Commerce.

TABLE 29

ESTIMATED 1971 USE PATTERN FOR SODIUM CHROMATE AND BICHROMATE
(Thousands of Tons)

End-Use	Consumption
Pigments	36.2
Chromic acid	32.0
Leather tanning	28.0
Metal treating	16.2
Textiles and dyes	10.1
Miscellaneous	19.0
Total	141.5

Source: Contractor's estimates.

TABLE 30

PRODUCTION OF CHROMIUM PIGMENTS AND CONSUMPTION OF SODIUM BICHROMATE EQUIVALENT, 1971

(Thousands of Tons)

Pigment	Production	Consumption of Bichromate Equivalent
Yellow and Orange	29.0	14.8
Oxide Green	6.6	9.0
Molybdate Orange	11.4	5.9
Zinc Yellow	5.6	5.8
Chrome Green	2.7	0.7
	55.3	36.2

Source: U.S. Department of Commerce and Contractor's estimates.

for light metals and steel. For example, in combination with red lead it is used in priming structural steel. It also is part of the formulation for automotive body prime coats. Sodium bichromate-based pigments are also used in printing inks and plastics.

The second largest outlet for sodium bichromate is for the manufacture of chromic acid, produced by reacting concentrated sulfuric acid with sodium bichromate. Chromic acid, in turn, is used primarily in chrome plating processes but also finds use in copper stripping, aluminum anodizing and for general corrosion prevention. The automotive industry represents the major user for chrome plating, although other durable goods manufacturing such as appliances also have requirements. Chromic acid imports have constrained domestic production.

The third most important outlet for sodium bichromate is leather tanning. With the exception of heavy cattle hides, where vegetable tanning is used, chrome tanning is the most important treatment for all hides (i.e., calfskins, goat- and kidskins, sheep- and lambskins). Chrome tannage is used in shoe uppers, glove leathers, garment leathers, and bag leather. In the tanning process, sodium bichromate is reduced with glucose to make the solutions of chromium salts employed in chrome leather tanning.

Various metal treating and finishing processes are the next most important outlet for sodium bichromate. For example, a solution of sodium bichromate and sulfuric acid is used in the bright dipping of brass and copper to remove oxide scale. Another important use in metal finishing is in the formation of chemical conversion coatings to provide corrosion protection and decorative effects, as well as to provide a good base for painting metal surfaces.

In the textile industry, sodium bichromate is used in a variety of ways. For example, among its applications are mordanting of wool, dyeing nylon and wool, dyeing with chromate colors, as an after-treatment on cotton to retard fading of dyes during washing and for stripdyed wool.

A miscellaneous category of uses, including chemical applications, wood preservative applications and corrosion control, accounted for approximately 13% of U.S. sodium bichromate consumption in 1971. A small quantity of sodium bichromate is used in the oxidation of various organic chemicals, including pharmaceuticals. The bleaching of fats, oils, and waxes also requires use of the bichromate as an oxidant. Perhaps the major chemical use for sodium bichromate is in the manufacture of catalysts. Chromates and bichromates are an important ingredient in the preservatives and fire retardants used by the wood preserving industry. Chromates are also used to inhibit corrosion in recirculating water-based systems (e.g., in cooling towers and large central air conditioning facilities).

b. Substitute Products

The primary substitution effect is represented by alternate materials (or processes) for derivatives of sodium bichromate rather than for the bichromate per se. As an example, aluminum or high-impact plastics can be substituted for chrome plated trim on motor vehicles. (It should be noted that processes have been developed to chrome plate plastics, e.g., ABS, although uncoated plastics are also used in automobile trim.) As another example, cadmium yellow can be used in place of chrome yellow pigments. Market growth for chrome leather is limited by lower cost substitutes, specifically, the poromeric materials. Tin-free steel cans coated with chrome compete with aluminum cans and seamless, deep-drawn steel cans coated with tin. The existence of these alternate materials both limits market growth and represents a constraint on higher sodium bichromate prices.

c. Captive Requirements

Table 31 presents Commerce Department data for sodium chromate and bichromate production, shipments, and shipment value for the period 1960 to 1971. Excluding inventory fluctuations and losses, the difference between total production in any given year and the quantity of shipments reflects the amount of sodium bichromate consumed at the producing plants for derivative manufacture. In recent years, this has amounted to about 50,000 tons or approximately 33% of total production. Including inter-plant transfers, captive consumption by the industry approximates 35% of production.

3. Supply Characterization

a. Manufacturing Routes and Economics

Sodium chromate and bichromate are made by calcining chrome ore (chromite) with soda ash or with soda ash and lime. More specifically, sodium chromate is manufactured by calcining a mixture of chromite ore, lime, and soda ash. The sodium chromate, if desired, can be recovered by leaching and crystallization. Sodium bichromate is produced by treating a sodium chromate solution with sulfuric acid. Sodium bichromate and the sodium sulfate by-product produced are separated and recovered by crystallization. Sodium bichromate is the principal commercial product because it is usually priced to cost less per unit of CrO_3 than sodium chromate.

As indicated, chromium chemicals are produced from chromite ore, the term chromite being a general one used to designate chromium-bearing spinel. The composition of chromite varies widely, usually with inclusions of magnesia, alumina, and silica. Although distinctions are not clearcut, there are three broad grades of chromite--high chromium chromite, a metallurgical grade; high-iron chromite, which is the chemical grade; and high-aluminum chromite, the refractory grade. Chromite

TABLE 31

SHIPMENTS OF SODIUM CHROMATE AND BICHROMATE

Year	Production (M Tons)	Shipments* Quantity (M Tons)	Value ($ MM)	Unit Value ($/Ton)
1960	121.9	89.1	22.7	254.77
1961	120.9	85.2	20.5	240.61
1962	127.5	97.0	24.8	255.67
1963	133.9	88.2	21.2	240.36
1964	137.9	99.6	22.9	239.92
1965	141.0	103.7	24.2	233.37
1966	141.5	94.2	23.9	253.72
1967	135.3	94.0	23.0	244.68
1968	146.1	100.0	23.9	239.00
1969	152.6	97.5	23.1	236.92
1970	153.5	103.2	24.8	240.31
1971	138.2	88.2	21.9	248.30

*Including interplant transfers.

Source: U.S. Department of Commerce.

has not been mined in the U.S. since 1961, when a small tonnage was produced under the government's Defense Production Act. With the exception of government stockpile releases, U.S. producers of chromium chemicals are therefore dependent on foreign sources. No commercially feasible process for upgrading domestic chromite bearing materials to compete with foreign ores has been developed.

Most of the known world reserves are located in the Republic of South Africa and Southern Rhodesia. The embargo on chromite from Southern Rhodesia, brought about by United Nations action in 1966 and an Executive Order in 1967, resulted in the U.S. turning to the U.S.S.R. for some of its chromite requirements. Most of the chemical grade chromite, however, comes from the Republic of South Africa.

Estimated manufacturing costs for sodium bichromate are shown in Table 32. The manufacturing cost estimates are based on a plant with 150 tons per day capacity and an investment (assuming the plant was built in 1960) of $5.7 million. The indicated manufacturing cost is $212. Included in this total is the cost of producing by-product sodium sulfate, amounting to approximately $20 per ton of bichromate.

Assuming a 1972 selling price for sodium bichromate of $245 per ton, plus by-product credit for 0.8 tons of sodium sulfate valued at $17, the total unit sales value is $262. Taking GS&A at 5.5% of sales, the indicated after-tax profit is $18.50 per ton for an after-tax return on sales of 7.1%.

b. Supply/Demand Balance

The producers of sodium bichromate are shown on Table 33. The two largest producers, Allied Chemical and Diamond Shamrock, have heavily integrated positions, both with respect to raw materials and derivative products. For example, Allied is a major producer of soda ash and sulfuric acid, and, along with Diamond Shamrock, is a major producer of chromic acid. Similarly, Diamond Shamrock produces both soda ash and sulfuric acid and several other derivatives of sodium bichromate in addition to chromic acid. PPG Industries produces soda ash at Corpus Christi and has nominal captive outlets for the sodium bichromate in pigments. Hercules, Inc., had produced bichromate in a small (approximately 30 tons per day) plant in Glens Falls, N.Y., for captive consumption in pigment manufacture. This facility has been closed.

The newest facility of the three producing plants is Diamond Shamrock's. Diamond Shamrock brought its Castle Hayne, North Carolina, facility on-stream late in 1971. The new plant replaced two older, less efficient plants at Painesville, Ohio, and Kearny, New Jersey. Including Diamond's new facility, total industry capacity is estimated at 175,000 tons per year. Compared with reported production of 137-138,000 tons per year, the industry operating rate in both 1971 and 1972 was slightly under 80%.

TABLE 32

ESTIMATED MANUFACTURING COST, SODIUM BICHROMATE

Production: 150 Tons/Day sodium bichromate
Operation: 330 operating days
Investment: $5,700,000 (Assuming plant was built in 1960)

Item	Units	US$/Unit	Units/Ton	Cost (US$/Ton Product)
Raw Materials				
Chromite (44% Cr_2O_3)	short ton	19.00	1.30	24.60
Soda Ash (Na_2CO_3)	100 lb	2.40	17.00	40.80
Lime (CaO)	short ton	20.50	0.80	16.40
Sulfuric Acid (66°Be)	short ton	26.00	0.50	13.00
Utilities				
Power	MKwh	15.00	0.50	7.50
Fuel	MMBtu	0.70	40.00	28.00
Water	MGal	0.10	14.00	1.40
Direct Labor				
Supervisors	Man-hr	7.50	0.17	1.30
Operators	Man-hr	5.00	3.40	17.00
Helpers	Man-hr	3.75	6.00	22.50
Overhead	60% Direct Labor			24.48
Maintenance				5.50
Maintenance Supplies				4.00
Depreciation	(3.0% of investment)			3.52
Taxes and Insurance	(1.3% of investment)			1.50
		Total Manufacturing Cost		211.50

Source: Contractor's estimates.

TABLE 32 (Continued)

MANUFACTURING COSTS FOR BY-PRODUCT Na_2SO_4

	Units	US$/Unit	Units/Ton	US$/Ton
Utilities				
Power	MKwh	15.00	0.10	1.50
Water	MGal	0.10	30.00	3.00
Direct Labor				
Supervisor	Man-hr	7.50	0.30	2.20
	Man-hr	5.00	1.00	5.00
	Man-hr	3.75	2.00	7.50
Maintenance Supplies	(0.4% of total investment)			0.50
Maintenance Labor	(0.2% of total investment)			0.20
Tax and Insurance	(0.1% of total investment)			0.10
				20.00

Source: Contractor's estimates.

TABLE 33

CURRENT PRODUCERS OF SODIUM BICHROMATE
(Thousands of Tons Hydrous Sodium Bichromate Equivalent)

Company	Location	Capacity
Allied Chemical Corp.	Baltimore, Md.	75
Diamond Shamrock Corp.	Castle Hayne, N.C.	70
PPG Industries, Inc.	Corpus Christi, Tex.	30
Total		175

Source: Trade sources.

4. Prices

A comparison of list prices versus actual prices as calculated from the Commerce Department data on reported value and quantity of shipments is shown in Table 34. Throughout the period, actual unit values realized by producers have been less than list prices. For example, in 1971 the actual price was 12.4 cents per pound versus a list price of 16.0 cents per pound.

List prices were increased by approximately 1 cent per pound in 1973 as they were in 1970 and 1971. Although shipment values for the industry for 1972 are not yet available from Commerce Department, actual prices received by producers are believed to have declined slightly. We have assumed an average industry plant price of $245 per ton in 1972 for our profitability estimates.

For the period shown, actual prices have varied very little. The static price pattern reflects low demand growth, competition from imports, the availability of substitute materials for derivative products, and an over-capacity situation in the industry. Static plant prices have been offset somewhat during this period by declining costs for the chromite ore. Bichromate producers are believed to have written favorable, long-term contracts for chromite ore. These contracts, however, will be phasing out over the next several years. Renegotiations will probably be at higher levels, reflecting both increased ore costs and higher ocean freights.

TABLE 34

ACTUAL VS. LIST PRICES FOR SODIUM BICHROMATE
(Cents per Pound)

Year	List Price[1]	Actual Price[2]
1960	13.00	12.74
1961	13.00	12.03
1962	13.00	12.78
1963	13.00	12.02
1964	13.00	12.00
1965	13.00	11.67
1966	14.00	12.69
1967	14.00	12.23
1968	14.00	11.95
1969	14.00	11.85
1970	15.00	12.02
1971	16.00	12.42
1972	16.00	Not available
1973	17.25	Not available

[1] Granular, bags, carlots, truckloads, works.

[2] Calculated from U.S. Department of Commerce reported value and quantity of shipments.

E. POTASSIUM CHROMATE AND BICHROMATE

While sodium chromate and sodium bichromate are by far the major chromium chemicals, a number of other chromium compounds are also produced from chromite ore. These secondary chromium chemicals include potassium chromate and potassium bichromate, ammonium bichromate, and chromium potassium sulfate. There are no government data for any of these materials on an individual basis. Commerce Department does report on an annual basis the dollar value of shipments for "other chromium compounds." In 1971, the most recent year for which data are available, the shipments of other chromium compounds were valued, f.o.b. plant, at $9.5 million. This dollar total has varied between $9.5 and $10.5 million for the last five reporting years.

Although potassium chromate and bichromate are the most important of the secondary chemicals, production of the potassium compounds in the U.S. only totals 3,000 tons annually. There are a variety of miscellaneous uses for potassium chromate and bichromate, the most important of which are pigments and reagent grade materials. Allied is the only U.S. producer of importance.

Potassium chromate and bichromate can be made by a process similar to that for producing sodium bichromate by substituting potassium carbonate for sodium carbonate in the raw material mix. However, potassium bichromate is normally made from sodium bichromate and potassium chloride. Estimated manufacturing costs for potassium bichromate are shown in Table 35. The sodium bichromate has been charged into the potassium bichromate process essentially at manufacturing cost. As indicated, total manufacturing costs were estimated at $402.75 per ton. Assuming plant netback at $475 per ton (the list price for potassium bichromate is 24¢ per pound) and GS&A at 5% of sales, the after-tax profit per ton is $24 per ton. This would be equivalent to an after-tax return on sales of 5.0%.

TABLE 35

ESTIMATED MANUFACTURING COST, POTASSIUM BICHROMATE

Production: 15 Tons/Day of Potassium Dichromate
Operation: 330 Working Days
Investment: $2,400,000 (Estimated)

Item	Units	US$/Unit	Units/Ton	Cost (US$/Ton Product)
Raw Materials				
Sodium Bichromate (content in solution)	ton	212	1.2	254.40
Potassium Chloride	ton	35	0.7	24.50
Utilities				
Power	MKwh	15	0.3	4.50
Fuel	MMBtu	0.7	15	10.50
Water	MGal	0.1	10	1.00
Direct Labor				
Supervisors	man-hr	7.50	0.6	4.45
Operators	man-hr	5.00	3	15.00
Helpers	man-hr	3.75	3	11.25
Overhead	(100% Direct Labor)			30.00
Maintenance Labor				4.00
Maintenance Materials				4.00
Depreciation	(6.5% of Investment)			31.95
Tax and Insurance	(1-1/2% of Investment)			7.20
			Total Manufacturing Cost	402.75

III. IMPACT ANALYSIS--INITIAL STUDY PRODUCTS

A. ALUMINUM CHLORIDE

1. Treatment Costs

As developed in the Development Document, water treatment costs for aluminum chloride producers total $3.77 annually per ton of product for E.P.P., B.P.T., and B.A.T. This amount would apply to plants operating on a chlorine-rich basis to produce yellow aluminum chloride, which is preferred for the manufacture of some dye and pigment intermediates.

Aluminum chloride plants operating on either a stoichiometric or aluminum-rich basis would have less waste chlorine stack gas and therefore lower pollution abatement costs. At least one producer is able to manufacture and sell 28% aqueous aluminum chloride solution derived from its scrubber effluents.

2. Price Impact

The maximum treatment cost of $3.77 per ton represents approximately 1.3% of the current selling price of aluminum chloride. Further, it is estimated that it will cost an additional 0.4% of the current selling price to concentrate the dilute scrubber solution for yellow aluminum chloride. Although capacity utilization (at about 65%), captive usage, and demand growth are relatively low, and therefore act as price increase constraints, these factors are outweighed by the low level of foreign competition, the absence of substitute products, and the existence of only a few products all with equal treatment costs. (All producers of yellow aluminum chloride will be faced with approximately the same water effluent charges.) Some level of price increase is therefore possible, and producers of aluminum chloride should be able to cover at least part of their added treatment costs. Any costs which could not be passed on as a price increase would have to be absorbed by the manufacturers.

3. Plant Shutdown Impact

No plant shutdowns are expected as a direct result of additional water pollution abatement costs. Given the moderate degree of integration, the fact that plants with a water pollution problem will have already made a large investment in air pollution abatement equipment, and a relatively high emotional commitment on the part of the aluminum chloride producers, the very low level of added cost for water treatment is too small to result in plant shutdowns.

B. ALUMINUM SULFATE

1. Treatment Costs

Water treatment costs for nonexemplary aluminum sulfate plants are estimated to be $0.93 per ton of product above existing B.L.P. treatment, or $1.72 per ton total. This added cost will raise average treatment level to zero discharge of process or cooling water effluent, which in this case is equivalent to E.P.P. Additional investment for a 40 ton-per-day plant is estimated to be $60,000.

The treatment process which will effect zero discharge involves clarification and additional pond settling of mud and digestion wastes, followed by recycle of process water. Depreciation and operating costs exclusive of power account for 46% and 23% respectively of total treatment costs.

2. Price Impact

Since there are no suitable substitute products, foreign competition is minimal, and market share is concentrated among several producers, water treatment costs will probably be passed on as small price increases. The amount of the increases, however, will vary with each producer's local competitive situation. Although before-tax treatment costs are small relative to product price, the cost per ton of product is highly dependent on plant capacity, which varies from 5,000 to 70,000 tons per year for individual facilities. Such a disparity in capacity will enable the large producer to cover his unit treatment costs with a smaller price increase than the small producer will require.

The nature of the aluminum sulfate market, however, will probably allow most smaller producers to continue operations at reduced profit levels. Many small plants have been located near paper mills in order to supply aqueous aluminum sulfate economically for paper manufacture. Despite higher unit production costs, a smaller plant can supply at a lower delivered cost than a larger, more distant plant can, due to the cost of transporting water solution. Aluminum sulfate is sold dried and bagged only where plants and customers are widely scattered, and the product must be transported long distances. It is anticipated, therefore, that larger producers will raise prices to cover their increased costs as fully as possible. Smaller producers will probably raise prices only to the point where they can still marginally undersell their larger, more distant competitors--a point which most likely will not permit the small producer to fully recover his costs, but which will allow continued operation at lower profitability. In any case, it is not expected that prices need be raised more than 5% due to water treatment costs.

3. Plant Shutdown Impact

Recent years have seen the closing of some small plants and a trend toward larger, more efficient facilities. As demand for aluminum sulfate as a water treatment chemical increases, the trend toward larger plants should continue. A large scale shutdown of small aluminum sulfate facilities, however, is not expected to occur as the result of anticipated increases in water treatment costs.

A very few marginally profitable plants may shut down, but these plants probably would have shut down anyway as a result of competition from larger plants. These occurrences will most likely be limited to situations in which a small plant cannot raise prices enough to remain profitable, while still underselling a larger, more distant competitor, and added water treatment costs represent the final negative factor against continued operation.

Industry capacity should continue to be sufficient to supply demand, and no increase in imports, with accompanying detrimental effects on balance of payments, is anticipated.

C. CHLORINE AND CAUSTIC SODA

1. Treatment Costs

As estimated in the Development Document, the cost of water treatment for a 175 ton-per-day mercury cell plant to achieve effluent conditions equivalent to B.L.P. is $2.14 per ton of chlorine produced. B.L.P. was defined in the Development Document as reduction of mercury to less than 0.5 pounds per day. For the exemplary plant investigated, the same investment, and therefore the same cost, was sufficient to reduce mercury to E.P.P. standards, i.e., less than 0.15 pounds per day. An incremental cost of $0.60 per ton of chlorine above E.P.P. was estimated for catalytic conversion of sodium hypochlorite to sodium chloride, bringing the mercury cell plant to B.P.T. control level. An incremental cost of $0.86 per ton above E.P.P. was estimated to achieve zero discharge (B.A.T.) and involved B.P.T. treatment plus evaporation and reuse of sodium chloride.

Similarly, the Development Document has estimated that the unit cost (in terms of chlorine) to achieve B.L.P. standards for a 2300 ton-per-day diaphragm cell plant is $0.038 per ton, the treatment being restricted to settling ponds. The incremental cost for this same plant over and above B.L.P. to achieve E.P.P. standards is $0.254 per ton of chlorine. This same unit cost is estimated to achieve B.P.T., but the assumption is made that there are no incremental operating costs associated with B.P.T. because hydrochloric acid recovered is assumed equal to cost. There is an incremental investment of $430,000 estimated above E.P.P. to cover the installation of the hydrochloric acid plant for the chlorine tail gas. Finally, the incremental unit cost above E.P.P. to utilize B.A.T. standards for this plant is estimated at $0.52 per ton of chlorine.

As a percent of the estimated $100.90 industry average revenue in 1972 per ECU (1.0 tons of chlorine plus 1.1 tons of caustic soda), the before-tax unit cost above B.L.P. and E.P.P. (which are equal) for the mercury cell plant is 0.59% for B.P.T. and 0.85% for B.A.T. The comparable ratio for the diaphragm cell plant is 0.25% for E.P.P. and B.P.T. and 0.52% for B.A.T. Compared to the average industry profit margin of $4.12 per ton for mercury cell plants (estimated in the initial study project) the incremental after-tax cost for B.P.T. in the mercury cell plant represents 7.3% of unit profits while B.A.T. represents 10.4% of industry profits. The comparable figures for the diaphragm cell plant (using $4.33 per ton as average unit profit) are 2.93% for both E.P.P. and B.P.T. and 6.03% for B.A.T.

2. Price Impact

Chlorine/caustic producers have the theoretical option of attempting to recover water treatment costs through price increases for chlorine and/or caustic soda. In our judgment, the opportunity for defraying some or all the water treatment costs through higher chlorine prices is better than via raising caustic soda prices. Both capacity utilization and captive usage are atypically high on average for chlorine. Demand growth is good (at 6% per year) and foreign competition is non-existent. Although there are a relatively large number of producing companies (approximately 30), the water pollution abatement costs faced by mercury plants are not significantly different than those for diaphragm plants. The difference is insufficient to put the mercury plants at a significant disadvantage if prices were to be raised only to cover the water treatment costs experienced by diaphragm cell plants.

More severe constraints exist for price increases in caustic soda. Except for periods of abnormally low chlorine demand (e.g., that experienced in the 1970-71 recession), caustic soda has usually presented a disposal problem to most chlor-alkali producers. Because normal caustic soda demand growth has been insufficient to match caustic soda supply (which, in turn, is a function of chlorine demand), the excess caustic has been sold in competition with other sodium alkalis, notably soda ash, at distressed price levels. We expect a long-term continuation of the caustic soda excess and therefore continued down-side pressure on caustic soda prices.

3. Plant Shutdown Impact

On the basis of the treatment costs estimated in the effluent guideline Development Document (and mentioned above), and based on the conclusion that most if not all of the nominal incremental costs for water treatment will be passed on through chlorine price increases, we foresee no plant shutdowns for producers who have already achieved B.L.P. However, an estimated 13% of the mercury cell plants have not yet made this investment. Instead of the $0.86 per ton incremental costs mentioned above to reach B.A.T., these producers would be faced with a $3.00 per ton cost. Some of these producers, assuming that they tend to be marginal plants, but probably no more than 5% of the industry (one or two plants), would be subject to shutdown.

D. HYDROCHLORIC ACID

1. Treatment Costs

Treatment costs have been supplied for the chlorine burning process only, a method which accounts for at most 12% of total U.S. hydrochloric acid production. For a 40 ton-per-day chlorine-burning facility the total cost to apply B.A.T. is $0.30 per ton of product (100% HCl), and the incremental cost above B.L.P. is $0.05 per ton. The treatment process involves neutralization of weak acid effluent which is generated only during plant startup. According to the effluent guideline Development Document there is no steady-state waterborne effluent.

Additional investment required for B.A.T. for the 40 ton-per-day plant is only $5,000. Depreciation and operating costs exclusive of power account for 35% and 47% respectively of the total annual treatment cost of $4,250.

By-product production of hydrochloric acid from hydrocarbon chlorination (which accounts for 88% of total production) was not covered in the effluent guideline Development Document. The effluent guideline Development Document indicated, however, that there are no water treatment costs directly attributable to by-product production.

2. Price Impact

Due to its overwhelming preponderance of production capacity, the by-product route controls hydrochloric acid supply and prices. By-product acid will not have to bear the direct water treatment costs which burning plant acid will; hence, it is not anticipated that the treatment costs incurred by a small industry segment will be passed on as general price increases. The likelihood of no increase is further supported by the presence of many producers holding fragmented market shares and the fact that, despite a recent trend toward a more balanced supply/demand situation, production has exceeded consumption by as much as 32% since 1961. This situation has been brought about by by-product acid supply being a function not of hydrochloric acid demand, but of the non-related demand for chlorinated hydrocarbons and has had a strongly depressing effect on hydrochloric acid prices. The decreasingly small portion of the industry which is faced with water treatment costs, therefore, will be hard pressed to seek relief in the form of price increases and will be forced to absorb these costs.

3. Plant Shutdown Impact

Only those direct producers not in a chlor-alkali complex face the possibility of plant shutdown as the result of water treatment costs. The weak acid waste stream from direct production in a complex can be used to neutralize caustic waste from other parts of the complex, and the producer essentially incurs no waste treatment cost on hydrochloric acid.

There is only one known isolated, direct burning plant in the country, and it is located near a larger chlor-alkali complex which provides a readily available site for waste acid disposal at nominal cost. The fact that there are no direct burning hydrochloric acid plants unable to dispose of water wastes at nominal cost leads us to conclude, therefore, that water treatment costs will not directly result in shutdowns of direct-burning hydrochloric acid plants.

E. HYDROFLUORIC ACID

1. Treatment Costs

As estimated in the effluent guideline Development Document, total treatment costs for a 40 ton-per-day hydrofluoric acid plant to achieve E.P.P., B.P.T. and B.A.T. are $4.04, $4.89 and $12.95 per ton, respectively. Costs for B.L.P. were estimated at $3.57 per ton. Annualized costs to to bring the industry to E.P.P., B.P.T. and B.A.T., respectively, from B.L.P. therefore would amount to $0.47, $1.32, and $9.38 per ton. As a percent of the estimated average industry's 1972 selling price of $370 per ton, the annualized treatment costs for E.P.P., B.P.T. and B.A.T. would be 0.13%, 0.36% and 2.54%, respectively.

The initial study project suggested a range for after-tax profitability on sales of 4% to 10%. Taking 5% as average, the after-tax profit margin on a $370 netback price would be $18.50 per ton. The after-tax treatment cost as a percent of this profit margin for E.P.P., B.P.T. and B.A.T. is 1.30%, 3.57% and 25.4%, respectively. New investment in treatment facilities for E.P.P., B.P.T. and B.A.T. as a percent of net fixed plant investment is 0.60%, 1.00% and 1.50%, respectively.

2. Price Impact

Conditions in the hydrofluoric acid industry are such that price increase constraints are low. Specifically, there are no economically viable substitute products for hydrofluoric acid in its major end-use applications. Captive usage is exceptionally high at about 75% of current consumption. Similarly, plant utilization is high at nearly 85% of the 392,000 tons of in-place capacity at the end of 1972. Demand growth is strong at 5% to 7% per year. Imports have been negligible so that there has been no threat of foreign competition. (Imports of hydrofluoric acid from Mexico will very probably increase in the future, however. Four U.S. companies have announced plans to build acid plants in that country with the apparent intent--initially at least--of using the acid captively for U.S. derivatives manufacture. There is the long-term possibility that increased pressure will be brought to bear by Mexico for manufacture of the derivatives of hydrofluoric acid in Mexico as well.) The price elasticity of demand for hydrofluoric acid is low. Market shares are relatively concentrated with two producers, Allied and Du Pont, accounting for more than 50% of capacity.

All of the foregoing considerations suggesting little or no constraint on price increases by far outweigh the two identified conditions tending to constrain price increases, viz. the relatively large number of producers (nine) and the fact that price is the primary basis for competition. Moreover, the magnitude of the price increase necessary to defray treatment costs even for B.A.T. (2.54% of the estimated industry selling price) is less than one-half cent per pound.

3. Plant Shutdown Impact

Since we have concluded that the industry would be able to pass on the treatment costs through price increases we must also conclude that there will be no plant shutdowns on the basis of the treatment costs provided us. The magnitude of these treatment costs on an after-tax basis as compared with industry profitability and cash flows and the magnitude of the treatment investment compared with net fixed investment for the industry support this conclusion. Moreover, industry conditions do not suggest the possibility of plant shutdowns. The industry is heavily integrated to downstream products (as inferred from the high captive usage), there are no overwhelming additional environmental costs to be defrayed and producers have an emotional commitment to the product.

F. HYDROGEN PEROXIDE

1. Treatment Costs

Based on the information developed for hydrogen peroxide in the effluent guideline Development Document, treatment costs to achieve B.A.T. are small relative to average selling price. For the electrolytic process, a process used by only one U.S. plant, the annual incremental treatment cost above E.P.P. and resulting in zero discharge would be approximately $0.39 per ton, or 0.07% of the current average selling price of about $596 per ton. The organic process, which is employed by five plants, leads to somewhat higher incremental costs for water pollution abatement. The incremental annual cost to achieve zero discharge via this process is $0.86 per ton. This added cost is also relatively small (0.14%) compared to the average selling price of hydrogen peroxide.

2. Price Impact

Although the potential impact on prices from water pollution abatement costs is small, producers of hydrogen peroxide may have difficulty in passing even these nominal costs on to customers through a price increase. The concentrated nature of the industry and the low level of substitute products are factors which would normally make it possible for producers to pass on increased costs, but the low level of capacity utilization (ca. 70%), low captive use (ca. 30%), some pressure on prices from foreign competitors, and differences in manufacturing costs due to plant size and processes used, are all factors which will make difficult any move to pass on the added treatment costs.

3. Plant Shutdown Impact

On the other hand, plant shutdowns as a direct result of such relatively small added water pollution abatement costs are also unlikely. The added costs may put some additional economic pressure on those producers whose plants are small and thus suffer diseconomies of scale. Additional plant shutdowns may occur as a result of normal economic forces, and thus smaller and/or older plants may be closed or placed on standby as capacity is adjusted to current demand.

There has been a trend in the industry to phase out the electrolytic plants, the economics of which are unfavorable compared to those operating by the organic process. The lower incremental cost for the electrolytic plant to achieve zero discharge may retard, rather than hasten, the decision to close this plant.

G. LIME

1. Treatment Costs

There are no waterborne wastes from the lime manufacturing process, and some plants (about 25% of the industry) have no waterborne wastes at all. According to the effluent guideline Development Document, those plants which do have waste-bearing water effluents are those which use wet scrubbing of gaseous effluent to remove entrained dust. While no costs were developed in the effluent guideline Development Document for wet scrubbing or treatment of scrubber effluents, the cost of installing a dry collection system (thereby avoiding waste-bearing water effluent) in a plant of 108,000 tons-per-year capacity was estimated at approximately $1.28 per ton annually. This cost of $1.28 per ton is taken as the maximum cost for zero discharge of waterborne wastes. It is recommended in the effluent guideline Development Document that water scrubbing and elimination of waterborne wastes be used whenever the total cost of such treatment is less than $1.28 per ton. One large plant plans to install a recovery system on the wet scrubber waste stream, the cost of which will be covered by product value obtained.

2. Price Impact

The annual treatment cost of $1.28 per ton for lime producers not currently using dry collection techniques represents a significant added cost relative to the average plant price for lime, which is approximately $16.00 per ton. A price increase of 8% would be required on lime produced at these plants to cover the maximum cost of water pollution abatement. Given a situation in which some lime producers will incur these costs while others will not, a price increase of this magnitude would only be tenable in a captive or quasi-captive situation in which a lime substitute (such as limestone in agricultural use) was not available, in which lime from another source could not be obtained at a lower (i.e., existing) price level, and in which the price increase could be passed on or absorbed by the lime consumer. In view of the nature of the lime industry, the large number of plants widely scattered throughout the country, and the competitive nature of industries using lime, such a situation is unlikely. A more probable situation would be one in which a lime producer using dry collection techniques, and not faced with increased water pollution abatement costs, would supply lime, on a freight-equalized basis, which could be priced lower than that supplied by a lime producer currently equipped with wet scrubbers. In summary, depending on the local supply/demand balance, a few plants may be in a position to pass on nearly all of the added treatment cost, many others only a fraction of the additional cost, and still others will be unable to pass on any added cost at all. Chances for success of some attempt to raise prices by affected lime producers will be improved by currently high capacity utilization and by forecasts of future growth.

3. Plant Shutdown Impact

According to information developed in the effluent guideline Development Document approximately 25% of all lime plants are equipped for dry bag collection of particulates. It is also reported that recovery of product which would otherwise be lost offsets the annual pollution abatement cost. The remainder of the industry has plants which use wet scrubbing, electrostatic precipitation, or some other method of dust control. Of the plants using wet scrubbers, only those classified as commercial (as opposed to captive) plants have been identified in the initial study project. These plants represented approximately 25% of the commercial plants identified in the study, and are the plants most likely to be affected by the implementation of more rigorous standards for waterborne wastes.

Typical profitability levels in the lime industry are reported to be from 4% to 6% of average selling price. At approximately $16.00 per ton, this would mean a maximum after-tax profit per ton of slightly under $1.00. Thus, if none of the added cost could be passed on, a producer forced to absorb up to $0.64 per ton after tax for water pollution abatement, would be left with less than half his normal profit from the sale of lime. Such a cut in profit levels for some producers could be the determining factor in a plant shutdown decision.

On this basis, we would expect that from four to ten plants may be closed. Since average employment in the lime industry is 35 persons per plant, this number of plant closings would mean that from 140 to 280 persons could be displaced. Fortunately, most plants having wet scrubbers are located reasonably close to urban areas and therefore in areas with potential employment alternatives.

H. NITRIC ACID

1. Treatment Costs

As reported in the effluent guideline Development Document, there are no direct waterborne process wastes and usually no waterborne wastes from air pollution abatement procedures in nitric acid manufacturing.

However, minor contamination of aqueous plant effluent may result from leaks, spills, and washdowns. It is also reported that 95% of the industry plants are at B.L.P. and that an incremental annual cost of $0.22 per ton would be required to install B.A.T.

It should be pointed out that these treatment costs, as developed in the effluent guideline Development Document, apply only to producers of commercial grade nitric acid (up to 70% concentration), and that the costs do not cover treatment of waterborne wastes from ancillary (cooling tower and boiler blowdown) effluent streams. In addition, nitric acid water treatment costs were assumed to be the same as those for sulfuric acid, since nitric acid cost figures were not available.

2. Price Impact

Approximately 90% of U.S. nitric acid production is captively consumed; the remaining 10% is typically offered for sale at a considerable discount from list price through long-term negotiated contracts. Based on dollar value and tonnage of 1971 shipments and interplant transfers, as reported by the U.S. Department of Commerce, the average selling price for nitric acid was $67 per ton. The reported maximum treatment cost for nitric acid, at $0.22 per ton, is approximately 0.3% of this average selling price. With both relatively low capacity utilization (ca. 75%) and demand growth, and with price as the main basis for competition, an across-the-board price increase to cover full incremental treatment costs is unlikely. The ability of individual producers to raise prices will depend on the competitive situation within each local market. However, some plants will undoubtedly be forced to absorb most of the added water treatment cost.

3. Plant Shutdown Impact

While some nitric acid plants may be shut down over the next several years as a result of normal economic forces, it is unlikely that the impact of added water pollution abatement costs, as developed in the effluent guideline Development Document, will be a significant decision factor. Plant shutdown decisions will more likely be based on such factors as low local capacity utilization, technological obsolescence of older plants, and the much higher cost of air pollution abatement.

I. SULFURIC ACID

1. Treatment Costs

Water treatment costs were estimated for plants using both sulfur burning and refinery acid sludge, which together account for 82% of all sulfuric acid plants. B.A.T. costs for sulfur burning were estimated at $0.12 per ton of product and for sludge regeneration at $0.50 per ton in both cases as increments above B.L.P. costs. For a 140,000 ton-per-year sulfur burning plant water treatment facilities investment is

$110,000, representing 3% of existing net plant investment. A 262,000 ton sludge plant, however, would require an additional investment of $1.15 million or 45% of existing net plant investment. The burning plant's water treatment operating costs are estimated at $24,000 per year, of which two-thirds is depreciation, with no direct operating or power costs. The sludge plant, on the other hand, will incur annual costs of $197,500 for B.A.T., with depreciation accounting for $125,000 and operating costs exclusive of power amounting to only $10,000. The treatment process in both plants entails neutralization of weak acid and isolation and containment of suspended solids.

2. Price Impact

We believe that water treatment costs can be passed on as a price increase. The amount and conditions for increase, however, are different for the two types of plants covered. Sulfur burning plants, the majority of which produce acid for non-refinery use, should incur water treatment costs which amount to only 0.6% of present selling price. Since these plants are concurrently encountering substantial air pollution control costs, it is expected that the relatively nominal water treatment costs will be passed on as part of joint air/water pollution control costs. Exact amounts of price increases will be dependent on local competitive conditions and the total amount of joint treatment costs to be passed on.

Refinery sludge plants, however, are in a special situation in that they are performing a service primarily for petroleum refiners who have no economical alternative for waste acid disposal. One sludge acid plant frequently handles the acid sludge streams of several refinery complexes since it is not economical for any but the largest refineries to have their own acid plants. Due to the sludge plant's higher investment and operating costs, higher prices are artificially maintained to provide the sludge operator with a profit equivalent to burning plants. In addition to air pollution costs comparable to those of sulfur burning, it is anticipated, therefore, that all of the water treatment costs, which amount to 10% of current selling price, will be passed on to refiners as price increases. Only the largest refiners will have the option of constructing their own sludge plant rather than accept higher prices.

3. Plant Shutdown Impact

Plant shutdowns due to water treatment costs alone are unlikely except for some sludge plants. For most non-sludge plants water treatment costs are not of sufficient magnitude to be the direct cause for plant shutdown. Some refinery sludge plants (no more than three or four) however, may face shutdown as a result of two special situations. In addition to returning fresh acid to local refineries, most sludge plants sell regenerated acid to commercial markets with the percentage of commercial business ranging from 10% to 100%. Since sludge producers face higher water treatment costs, the occasional producer dependent on a large percentage of commercial demand will be at a competitive disadvantage to the sulfur burning producer. The sludge producer must cover high fixed costs through high capacity utilization, a condition which could be difficult to maintain if competitive burning plants under-price the sludge manufacturer. Due to water treatment costs, therefore, a sludge producer may face reduced profitability in the commercial market, either through reduced sales margins or through smaller capacity utilization, sufficient to warrant shutdown.

The other problem facing the sludge producer is the possibility of a refinery switching to captive sludge acid regeneration. This action is not likely since only a few refineries are large enough to economically operate their own acid regeneration plants. In addition, multi-site refiners may be reluctant to antagnoize sludge producers by going to captive acid regeneration at one location while continuing to utilize the sludge converter at another site.

IV. IMPACT ANALYSIS--MAJOR STUDY PRODUCTS

A. CALCIUM CARBIDE

1. Treatment Costs

The calcium carbide manufacturing process has no direct waterborne wastes, the only sources of effluent contamination being cooling tower blowdown and ion exchange requirements. One producer of calcium carbide uses the dry bag collection technique for air pollution abatement and has no significant water pollution abatement costs. The value of material recovered affects treatment costs in this case. Another producer, not yet having installed air pollution abatement equipment, is understood to be considering the dry bag approach.

The remaining two producers of calcium carbide, using water scrubbing for air pollution abatement, and representing approximately 85% of industry capacity, would have to isolate the scrubber effluent, remove suspended solids, and further treat the water before discharge. The annual operating expenses for such a scrubber effluent system are sufficiently large relative to after tax net income to make installation of a dry bag collection system--which, according to the effluent guideline Development Document, pays for itself from collection and recycling of raw materials and product--attractive even to those producers who have already installed scrubbers. For a small (50,000 ton per year) plant, the investment in wet scrubbers would be approximately $54,000, or 1.4% of net fixed investment. The annual treatment costs before tax, would be approximately $1.94 per ton.

The waterborne wastes from conversion of calcium carbide to acetylene are significant, and may have an additional impact on those plants at which acetylene is produced. We have not been provided with costs for the treatment of effluents which result from acetylene manufacture.

2. Price Impact

Producers of calcium carbide using air bags for air pollution abatement will have no added costs for control of waterborne wastes. Producers using water scrubbers and choosing to continue their use, thereby incurring water treatment costs of $1.94 per ton, or 2.2% of the estimated $90 per ton average selling price, would have difficulty in passing the added cost on to consumers. Price increase constraints for calcium carbide are strong, and in view of available substitutes, current overcapacity, and a declining market, any price increase would only serve to further reduce demand.

3. Plant Shutdown Impact

While continued plant shutdowns may be expected as a result of economic forces over the next several years, the effect of water pollution abatement costs related to the manfuacture of calcium carbide are expected to be relatively small. As is the case with many of the other chemicals in this study, air pollution abatement costs are considerably larger than those for control of waterborne wastes. Thus, the marginal plants have already been culled as a result of air pollution abatement impact, and those remaining plants which have not installed dry collection systems, either have sufficient commitment to bear the marginally small additional cost of scrubber effluent treatment, or to make the initial investment in a reportedly profitable air bag system. In the worst case, that of a contract supplier operating at the break-even point, it is estimated that annual cash flow from depreication would cover annual water treatment operating expenses.

Calcium carbide plants which immediately convert their product to acetylene gas have the additional problems of handling the calcium hydroxide produced as a by-product. Water pollution abatement costs relating to acetylene production have not been supplied to us by EPA and it is beyond the scope of this report to assess the impact of these treatment costs. In general, however, acetylene producing calcium carbide plants tend to be captive or contract suppliers of calcium carbide acetylene.

Finally, as described in an earlier section of this report, the calcium carbide industry faces a continued declining market due to causes unrelated to environmental pollution abatement. In the normal product life cycle, calcium carbide seems to be well beyond maturity as more economical substitute products continue to gain a larger and larger market share.

B. SODIUM SULFATE

1. Treatment Costs

Treatment costs discussed in the effluent guideline Development Document pertain only to sodium sulfate produced as a by-product of sodium bichromate manufacture. These producers collect, dry, and sell the by-product, and reportedly have no waterborne wastes or treatment costs attributable to sodium sulfate.

Production of sodium sulfate as a by-product of sodium bichromate represents approximately 10% of total U.S. production. The most important source is recovery from natural brines, followed by production as a rayon and cellophane by-product.

2. Price Impact

With no water pollution abatement costs assigned to sodium sulfate as a sodium bichromate by-product (chrome cake) no effect on prices is expected for this product. It is unlikely, however, that a sodium sulfate price increase could be sustained in view of the high level of substitute products, foreign competition, excess capacity and a static or declining market.

3. Plant Shutdown Impact

Zero water treatment costs for producers of chrome salt cake mean no plant shutdowns. The bulk of U.S. sodium sulfate production is by producers for which no treatment costs have been developed, and therefore the impact of federal water pollution control costs on most producers of this chemical is beyond the scope of this report.

C. TITANIUM DIOXIDE

1. Treatment Costs

a. Sulfate Process

Two separate treatment approaches for sulfate process plants, acid neutralization and acid recovery, were discussed in the effluent guideline Development Document along with their respective costs. To utilize B.A.T. for a 42,000 ton plant, total treatment costs for neutralization are estimated to be $98.09 per ton, or 17.2% of current selling price, and for acid recovery $50.48 per ton, representing 8.9% of selling price. The investment in treatment facilities via either method is large--$11.5 million for neutralization and $5.5 million for acid recovery. These amounts represent respectively 55% and 26% of existing net plant and indicate the sizeable investment relative to existing plant required.

In the case of neutralization zero discharge treatment consists of solids settling, full neutralization of the waste acid streams, and the demineralization and recycle of process water. Annual costs amount to $4.12 million of which $2.35 million are operating and maintenance costs exclusive of power, and $1.15 is depreciation. The acid recovery process involves recovery and recycle of strong acid waste plus neutralization and pond settling of the remaining effluent. Annual costs for acid recovery are significantly less than those of neutralization and amount to $2.12 million. At $445,000, or 21% of the total, energy costs are high relative to the neutralization option. Operating and depreciation costs amount to another $850,000 and $550,000, respectively.

A major item of concern raised in industry interviews was the technical feasibility of the acid recovery option. For a number of years the industry has been attempting without success to develop an acceptable acid recovery procedure. Since treatment costs could be only one-half of those for neutralization, the EPA-sponsored research in this area is being watched with interest, but with considerable skepticism. Due to the uncertainty of successful development of acid recovery technology, therefore, our sulfate process water treatment cost impact analysis will be based on the neutralization method alone.

Water treatment costs for B.P.T. are not significantly lower than for B.A.T. For the neutralization method, investment drops only to $10 million and annual costs amount to $3.51 million, or 85% of B.A.T. costs. The last incremental step to B.A.T., therefore, is not significantly more expensive than full neutralization, and will probably not affect price increase/plant shutdown decisions significantly.

b. Chloride Process

Water treatment costs for chloride process wastes are estimated to be significantly less than those for the sulfate process. B.A.T. can be attained at a cost of $66.79 per ton for a 25,900 ton plant, which is a typical size plant in the industry. Total additional investment in treatment facilities for this plant is $5 million, which represents 23.5% of existing net plant.

B.A.T. annual treatment costs total $1.73 million, of which operating and maintenance costs exclusive of power account for $890,000 and depreciation another $530,000. The treatment process required to reach this level involves chemical neutralization of waste acid streams, thickening and land dumping of sludges, and removal of dissolved chlorides and sulfates through evaporation and recycle of process water. B.P.T. treatment, which is the same as E.P.P. and does not involve soluble chloride and sulfate removal, is considerably less costly than B.A.T. At $4 million and $1 million, treatment facilities investment and annual operating costs repsectively are 75% and 58% of corresponding B.A.T. figures. B.P.T. investment requirements and operating costs, therefore, are lower for chloride producers, both in absolute terms and in comparison with B.A.T. requirements.

c. Barging and Deep-Welling

Currently both cloride and sulfate wastes are being barged to sea by several producers. Sulfate barging involves deep sea dumping of strong acid, sludge, and metallic sulfate wastes and costs $8-10 per ton of product. Chloride waste barging consists of ocean dumping of strong acid and metallic chloride and oxide wastes, and costs are $5-10 per ton of product. Considerable pressure is being brought to bear by private groups to stop ocean dumping, and the future of this alternative is very uncertain. Use of barging is limited for the most part to those plants located on the coasts, and it represents a significant cost advantage over chemical treatment options.

Deep-welling is currently being used by at least one producer to dispose of chloride process wastes. Geological conditions limit deep-welling to certain parts of the country; thus, this method is not possible for all producers. Costs range from $2 to $5 per ton of product, again significantly lower than chemical treatment costs. As in barging the future of deep-welling is clouded due to unresolved questions as to the effects of deep-well wastes on surrounding water table structures. Clearly, however, if barging or deep-welling is allowed to continue by EPA, the producers fortunate enough to be able to utilize either method will incur significantly lower water treatment costs than those companies having to employ chemical neutralization methods.

2. Price Impact

It is most probable that some part of water treatment costs would be passed on as price increases. There are several major reasons for this likelihood. In the face of a strong demand which is projected to continue for several more years, capacity will remain strained through at least 1975 when additional production facilities should come on stream. The industry is presently at 100% of practical capacity and is allocating product to customers. Secondly, there are no known substitute products which match titanium dioxide for cost effective hiding power. Foreign competition for the foreseeable future will be minimized through recent currency devaluations, the tight supply situation present in Europe, and the fact that European producers are themselves beginning to feel pollution control pressures. Lastly the water treatment costs estimated for the titanium dioxide industry are among the largest encountered for any chemical in this study. Pre-tax B.A.T. costs account for fully 16.8% of sales price for sulfate pigments, and 11.3% of sales price for chloride pigments. Applying these costs against our estimates of industry profitability, it becomes apparent that price increases would be necessary to avoid negative profitability as a direct result of water treatment costs.

At the present time the differential between sulfate and chloride process treatment costs poses a complication in assessing the magnitude of price increases for titanium dioxide pigment. The chloride producer, faced with treatment costs for B.A.T. of $0.033 per pound can obtain relief with a smaller price increase than the sulfate producer, who must cope with treatment costs of nearly $0.05 per pound. Industry sources believe that, for the next two to three years, the supply/demand situation for titanium dioxide pigment would permit sulfate producers to raise prices more than chloride producers in order to recover their higher water treatment costs. Such a differential could not exceed $0.01 to $0.02 per pound, especially in view of the chloride pigment's superior performance in many applications, and it could not be sustained if additional capacity were brought on stream or if imports become more price-competitive. It is most probable that chloride producers would raise prices only enough to cover their own treatment costs, since raising prices by the same higher amount as sulfate producers may require would increase chloride process profitability to the point where new competition would likely be encouraged. B.P.T. treatment would lower the absolute treatment costs for both chloride and sulfate producers, but would also widen the differential in treatment costs for the two processes by almost $0.007 per pound. The sulfate producer would thus be placed at an even greater disadvantage relative to the chloride producer.

3. Plant Shutdown Impact

The probability of plant shutdown is difficult to assess because of the uncertainty in the amount and duration of price increases, and the resultant profitability effects, based on water treatment costs. Sulfate producers are most likely to face plant shutdown decisions because of the age of most sulfate plants and the extremely high treatment facilities' investment projected. Confronted with an investment amounting to 50% of existing net plant, and the prospect of long-term negative profitability if prices cannot be raised to fully cover treatment costs, industry sources report that a shutdown decision would probably be made. This decision would be complicated by the prospect of continued positive cash flow from full capacity operation in the presently strong market. However, the recent closing of a chloride facility by NL Industries, even in the face of the presently strong market, indicates that producers might shut down an operation burdened with continued negative profitability.

We conclude, therefore, that over the long range one or two smaller sulfate facilities might shut down as a result of water treatment costs. The actual closings could be delayed as the producers attempt to compete in the favorable pigment market as long as possible, but we feel that the magnitude of investment and annual costs would eventually make shutdown a necessity. The chloride producers will probably be less affected by water treatment costs and we do not anticipate any chloride facility closings as the direct result of these costs.

4. Impact Analysis Sensitivity

We have assessed the sensitivity of our impact conclusions for titanium dioxide if treatment costs are higher than those estimated in the effluent guideline Development Document. We conclude that if costs are in fact understated by a factor of four, the impact on the titanium dioxide industry will be severe and substantial plant shutdown could be expected especially among sulfate producers.

With a fourfold increase in treatment costs over those shown in the effluent guideline Development Document, pre-tax costs for B.A.T. would be $0.12 per pound or 45.2% of present selling price for chloride pigment and $0.19 per pound or 67.2% of present selling price for sulfate pigment. Impact on after-tax net income and cash flow is even more severe. B.A.T. treatment costs for chloride pigment are 948% and 136% of net income and cash flow respectively, and 932% and 261% respectively for sulfate pigment. B.A.T. costs would thus exceed both net income and cash flow, and plant shutdowns would be inevitable.

Implementing treatment procedures to use B.P.T. only would reduce the absolute magnitude of treatment costs, but would widen the differential between chloride and sulfate costs and subsequent impact effects. B.P.T. costs pre-tax would be $0.07 per pound, or 25.6% of selling price for chloride pigment, and $0.16 per pound, or 57.2% of selling price for sulfate. Both chloride and sulfate pigment would show negative profitability, but chloride cash flow would remain positive (after-tax treatment costs of 78.6% of cash flow). Sulfate pigment, with after-tax costs representing 223% of cash flow, would continue to show negative cash flow. We conclude, therefore, that substantially higher treatment costs, even with B.P.T. treatment, would result directly in plant shutdowns, and that the sulfate producers would be more severely affected.

As pointed out earlier, it should be possible for producers to obtain relief by passing some of the treatment costs along as price increases. If costs are adjusted upward by a factor of four, however, it is doubtful that this new level of treatment costs could be passed on in full. While titanium dioxide has no equally cost effective substitutes at its present price level, a price higher than about $0.40 per pound makes substitution by high brightness clays and other pigments economically attractive. Due to the surface properties it imparts, especially in paints, titanium dioxide will not be completely replaced, but its demand would be curtailed via substitution. A secondary limitation on the magnitude of potential price increases is price competitiveness of the final product in which titanium dioxide is used. Paint prices, for instance, cannot be raised substantially without losing business to other wall covering materials such as wallpaper or wood paneling. A titanium dioxide price of $0.40 per pound would result in a $0.15 per gallon increase in paint price, assuming 1.3 lbs. of titanium dioxide per gallon of paint and no substitution by cheaper pigments.

Passing on B.A.T. treatment costs in full would result in a price increase to the $0.40 per pound range for chloride pigment and to nearly $0.48 per pound for sulfate. We believe, therefore, that B.A.T. treatment costs would not be passed along completely. Passing on B.P.T. treatment costs in full will result in a more tolerable $0.35 per pound price for chloride pigment, but will still leave sulfate pigment, at nearly $0.45 per pound, susceptible to replacement by lower cost pigments. Sulfate producers would most likely be able to recover only $0.07-$0.08 per pound of their treatment costs via a price increase to $0.36-$0.37 per pound. In this situation, the industry would be operating with chloride producers fully recovering their costs and maintaining existing profitability and with sulfate producers operating with negative profitability and negligibly positive cash flow. We would expect, therefore, that even at B.P.T. treatment, price increases would not be sufficient to avoid major impact on titanium dioxide production, especially for sulfate pigment.

D. SODIUM CHROMATE AND BICHROMATE

1. Treatment Costs

The effluent guideline Development Document has estimated treatment costs for a 164 ton-per-day sodium bichromate plant to achieve E.P.P., B.P.T. and B.A.T. at $11.66, $16.45, and $16.45 per ton, respectively. E.P.P. control involves segregation and chemical treatment for chromium-6, followed by pond settling and discharge of clear effluent to surface water. B.P.T. involves evaporation to recover dissolved sodium chloride in addition to E.P.P. control. The incremental unit costs above B.L.P. (settling ponds estimated to cost $0.26 per ton), therefore, are $11.40 per ton for E.P.P. and $16.19 per ton for B.P.T. and B.A.T.

As a percentage of the estimated 1972 industry selling price of $245 per ton, E.P.P. costs amount to 4.6% while B.P.T. costs on an incremental basis amount to 6.6%. As compared to the estimated 1972 after-tax profit margin of $18.50 per ton, the incremental cost to achieve E.P.P. effluent standards is 30.8%, while achievement of B.P.T. standards would represent 43.7% of 1972 unit margins.

2. Price Impact

On balance, factors constraining price increases in the sodium bichromate industry outweigh those factors suggesting that price increases are possible. Specifically, the high occurrence of substitute product for sodium bichromate derivatives, the tough foreign competition (including imports of sodium bichromate per se, as well as imports of derivatives such as chromic acid and chrome colors) and declining future demand all argue against the possibility of price increases. Moreover, abatement cost differences exist among the three producers. The exemplary plant, for example, has already achieved E.P.P. and need make only a relatively nominal investment to utilize B.P.T. These negatives outbalance those industry factors--viz. the small number of producers (three) and concentrated market share distribution--which would tend to make price increases possible. We conclude, therefore, that the full cost of water treatment control will not be passed on as price increases.

3. Plant Shutdown Impact

In view of the conlusion that additional water treatment costs will be absorbed, there is a possibility that one of the three sodium bichromate plants will be shut down. Full absorption of the treatment costs to achieve B.P.T. would represent very nearly a 50% reduction in after-tax unit profit margins. Moreover, there is the possibility that current margins will be reduced from 1972 levels (even without increased water treatment costs) by virtue of higher future chromite ore prices. The incremental investment ($1.7 million) for water treatment control is relatively high in comparison to the investment in existing plant. The three plants are isolated and could not achieve treatment economies with other company products. Finally, the industry faces in addition to water treatment investment both air pollution and above normal OSHA costs. With respect to the latter, the toxic nature of chromium will require safety measures beyond normal plant practices. Although on a superficial basis the industry is integrated both backward and forward, the raw material requirements--soda ash and sulfuric acid--are insufficient to justify continued operation on that basis alone. Similarly, the primary downstream derivative--chromic acid--is considered part (and a less important part) of the chromate operation. If the sodium bichromate plant were considered uneconomic, the chromic acid facility would be shut down as well.

V. IMPACT ANALYSIS--ADDITIONAL PRODUCTS

In this section, we have provided: (a) summary comments of expected economic impacts on each of the additional products and (b) back-up commentary for the summary comments only on those critical points as indicated by the impact analysis matrix. Specifically these points were those: (a) which mitigated against the possibility of the producers' raising prices to cover the additional cost for effluent treatment; and (b) where treatment costs and estimated profitability were such as to affect a plant shutdown decision. As indicated by the commentaries for each individual product and the impact analysis matrix, we have tended not to comment on those individual factors which were not relevant to the impact judgment.

A. SODIUM BICARBONATE

1. Summary

We foresee no significant economic impact on the producers of sodium bicarbonate due to requirements to reach either exemplary plant practice, best practicable technology levels of treatment or best available technology levels. This conclusion is based on the extremely modest capital requirement and operating costs specified by the Development Document to reach necessary control levels and the apparent pricing flexibility available to the producers. The ability of the producers to raise prices over the past several years has been assisted by significant reductions in capacity at a time of relatively rapidly increasing demand. These capacity reductions were brought about by the closing down of two Solvay process sodium carbonate plants which served as sources of raw material for the production of sodium bicarbonate by these companies.

2. Price Impact

As shown in the impact analysis matrix, the costs of effluent control are an extremely small proportion of the selling price. Increases in selling price in the past decade have been of such magnitude as to dwarf the control cost to insignificance. We foresee no reason that future price increases could not be effected to offset additional control costs and in fact, it would not even be noticed in the trend of rising prices. The list price for sodium bicarbonate in 1952 was at $2.10 per hundred weight. This prevailed until 1967 when it was raised to $2.55 per hundred weight. By 1966, it was again increased to $2.80 per hundred weight and in 1969 to $3.10 per hundred weight. By 1970, the price had increased to $3.40 per hundred weight and by 1973 to $4.40 per hundred weight.

The average price has quite probably been somewhat lower than the list price published for sodium bicarbonate. The average prices as calculated from the current industrial reports of the U.S. Department of Commerce are, however, probably more misleading than list prices. This government data provides tonnage of finished bicarbonate shipped and the value. In 1971, this calculated to $49.00 per ton. These "average" prices, however, are probably distorted by the relationship that exists between Church and Dwight and Allied Chemical. Church and Dwight markets both crude and high purity sodium bicarbonate manufactured by Allied Chemical in Syracuse, New York. The company also operates a sodium bicarbonate plant in Green River, Wyoming, to convert trona to sodium bicarbonate. The Government data may include shipments of crude product to Church and Dwight's plants, thus distorting the average price.

As shown in the impact analysis matrix, only a low captive usage and the relatively low demand growth would indicate on a theoretical basis the difficulty in raising prices. We do not believe in practice, however, that either one of these considerations will tend to limit future price increases so as to offset the modest cost of effluent treatment.

a. Capacity and Captive Consumption

Estimated producers capacities in 1973 are as follows:

Church and Dwight, Green River, Wyoming	100,000 tons
Church and Dwight, Syracuse, New York	100,000
Diamond Shamrock, Painesville, Ohio	28,000
BASF Wyandotte, Wyandotte, Michigan	36,000
	264,000 tons

These producers sell a great majority of their production of sodium bicarbonate for application in the manufacture of industrial or consumer products. The food industry takes 35-40% of the total bicarbonate shipments, rubber and chemicals take about another 20%, the pharmaceutical requirement is around 13%, and fire extinguishers about 12%. The remainder is used in the soap and detergent industry, textile, paper and leather industry. The major marketer, Church and Dwight, does account for some captive consumption through consumer sale of sodium bicarbonate under the Arm & Hammer brand.

The significance of the relatively low captive consumption in the price restraint is small when considered in the light of the small number of producers competing for the business and the relatively high capacity utilization. Capacity utilization has been assisted by both an increase in a recent growth of demand and, more significantly, by the shutting down in 1971 of a 23,000 ton per year plant of Olin Corporation and a 35,000 ton per year unit of PPG. Reportedly, these units were closed down because the Solvay process soda ash plants, which provided raw material for the manufacture of sodium bicarbonate, were uneconomical.

b. Demand Growth

Sodium bicarbonate is a relatively mature product with only modestly increasing demand. The U.S. Department of Commerce current industrial report indicates shipments of sodium bicarbonate expressed as soda ash increasing from 100,000 tons per year in 1961 to 156,000 tons per year in 1971, or at an overall rate of 4 1/2% per year. The demand growth rate increased somewhat over the last five years to an average of 6% per year. No substantial change in the 10-year growth rate is foreseen for the remainder of the decade.

Growth in demand has been steady over the past decade with each year's requirements larger than the previous. There are no apparent or announced plans for significant expansion; therefore, the outlook for the foreseeable future is that capacity utilization will remain relatively high in spite of a modest growth in demand.

c. Basis for Competition

Sodium bicarbonate like other commodity chemicals is sold on specification. The exception to this is the consumer sales of sodium bicarbonate under the recognized brand name. As indicated above, we believe that this is a relatively small proportion of total U.S. requirements.

Actually under present conditions, competition is probably not only on the basis of price but also on the basis of assured supply. Even during periods when the capacity was more significantly in excess of demand, this did not inhibit steadily increasing prices as described above.

3. Plant Shutdown Impact

The Development Document indicates annual treatment costs for a 100,000 ton sodium bicarbonate plant at $2500 a year under current practices. To reach best practicable technology or best available technology conditions requires a total of $4250 per year for the same plant. An increase of only $1750 per year, therefore, is required to go from current conditions to the more stringent effluent controls foreseen. As shown in the impact analysis matrix, this is an extremely modest proportion of the estimated total after tax net income. As estimated, sodium bicarbonate producers at present price levels received an 8% after-tax return. Even should this estimate be significantly higher than actual practice, it is hard to imagine that the very modest additional cost requirements for effluent control would significantly affect any decision on plant shutdown.

a. Integration

We have classed the degree of integration as low chiefly because there is very little forward integration in the industry. In a practical sense, there is a high degree of backward integration in the terms that Church and Dwight operates under long term commitments to Allied Chemical for the sale of sodium bicarbonate. The only non-integrated plant in the industry is Church and Dwight's facility in Green River, Wyoming, constituting about 40% of total capacity. This plant is operated on products supplied from Allied Chemical's trona facility at Green River. We assume that this facility is protected by a long-term contract with Allied and by the long standing relationship between Church and Dwight and Allied, whereby Allied has normally acted as the manufacturing partner and Church and Dwight the marketing partner for sodium bicarbonate.

b. Emotional Commitment

Emotional commitment of the producers is hard to assess. We assume that Diamond Shamrock and BASF Wyandotte would have little commitment to the manufacture of sodium bicarbonate. Church and Dwight, however, has not only developed a consumer marketing franchise but sodium bicarbonate and sodium carbonate constitute the bulk of sales of Church and Dwight Company Specialty Chemicals Division.

c. Ownership

As described, most of the capacity for the production of sodium bicarbonate is controlled by multi-industry concerns, Allied, Diamond Shamrock and BASF. All of these companies do have a variety of options for employment of capital. We do not foresee, however, that there are sufficient negative concerns indicating plant shutdowns so as to restrict the very modest investment required. The Development Document indicates that currently a 300 ton per day sodium bicarbonate facility has a $10,000 investment in water pollution abatement facilities and this need only be increased to $15,000 to meet all future effluent control standards.

B. SOLAR SALT

1. Summary

In the solar evaporation process, seawater or salt lake water is concentrated by evaporation over a period of five years in open ponds to yield a saturated brine solution. After saturation is reached (approximately 30° Baume) the brine is fed to a crystallizer where sodium chloride precipitates leaving behind a concentrated brine solution (bittern) consisting primarily of sodium, potassium, and magnesium salts.

According to the Development Document the bittern solution, which contains all of the wastes from the process, is presently stored (ponded) at all facilities. Consequently, the solar salt industry is faced with no incremental costs to achieve zero discharge and there will be no negative impact on solar salt producers from new water pollution abatement procedures. The Development Document estimates existing costs for bittern storage at the exemplary facility (annual capacity at very nearly 1 million tons) at $2.34 per ton.

2. Price Impact

Although the question is academic, examination of some of the competitive factors impacting on the solar salt industry indicates that if there were incremental costs associated with water treatment, solar salt producers would be hard put to pass much if any of the costs on as price increases.

a. Substitute Products

Solar salt is marketed as harvested (so-called "undried stack run") or further processed (via size classification and/or purification) before sale. When sold as such it competes with rock salt (valued F.O.B. mine at approximately $3 per ton) primarily for chemical markets (basically chlor-alkali production). When purified and classified by particle size it competes with vacuum pan evaporated salt at unit values ranging between $6 and $40 per ton. Therefore, there is no other chemical that competes with solar salt as a direct substitute. The other sources of salt--particularly rock salt for which there are no waterborne wastes--are significant constraints on the solar salt producers to raise prices unilaterally. (The only exception might be the use of calcium chloride as a replacement for sodium chloride in highway snow and ice control, but even here the use of calcium chloride is complementary rather than substitutive.)

b. Demand Growth

Although Commerce Department data for U.S. consumption of solar salt are not available, U.S. production of solar salt has exhibited a pattern of static to very slow growth. Actual production data for the last ten years in thousands of tons are as follows:

	Thousands of Tons
1972	1799
1971	1937
1970	1538
1969	1907
1968	1900
1967	1729
1966	1769
1965	1700
1964	1592
1963	1766

c. Foreign Competition

U.S. solar salt producers have been under extreme competitive pressure from Mexican imports of solar salt. The bulk of U.S. solar salt production is in California and to a lesser extent Utah. In 1972, Mexican imports of solar salt totaled 1.25 million tons with a unit value of $2.29 per ton. The competitive threat of low-cost Mexican solar salt also effectively constrains price increases by western U.S. solar salt producers.

d. Abatement Cost Differences

Water pollution abatement costs for U.S. solar salt producers are equal to foreign competitors (in that they are zero) and better than equal (in that they are less) with respect to U.S. producers of evaporated salt.

e. Price Elasticity of Demand

Increased prices for U.S. solar salt would result in reduced demand from consumers who have the option of increasing purchases of foreign solar salt or domestic rock salt.

3. Plant Shutdown Impact

With no new water treatment costs as indicated in the Development Document, there will be no solar salt plant shutdowns directly attributable to water pollution abatement measures. As indicated in the preceding paragraphs, however, if there were water treatment costs, solar salt producers would find it difficult to raise prices in order to pass on treatment costs.

C. EVAPORATED SALT

1. Summary

The Development Document has estimated incremental water treatment costs for both B.P.T. and B.A.T. for evaporated salt producers at $0.44 per ton. In comparison with the reported 1972 unit value for evaporated salt of $26.94 per ton, the cost of water treatment represents 1.64% of sales value. This relatively nominal percentage in combination with competitive conditions in the industry wherein the only constraints against price increases are low captive usage (essentially zero) and modest demand growth (2.5% per year in the post-World War II period) leads to the conclusion that evaporated salt producers will be able to pass on the added cost of water treatment through higher prices. It follows, therefore, that plant shutdowns as a result of new water pollution abatement standards are unlikely.

2. Price Impact

The only factors acting as constraints against price increases for evaporated salt in our format are low captive usage and relatively low demand growth. For practical purposes, there is no captive usage at all by evaporated salt producers--all production is sold to merchant consumers. In the context of the evaporated salt market, however, this factor is not a strong constraint against price increases. Similarly, although demand growth has been low (approximately 2.5% per year in the post-World War II period) demand increases have been steadily upward on a year-to-year basis. Although the U.S. evaporated salt market has not been characterized by dynamic growth, it has experienced consistent growth. These two weak price increase constraining factors are outweighed by the following considerations.

a. Substitute Products

There are few, if any, substitutes for evaporated salt in its major applications. The other primary forms of salt (rock or brine) don't compete with evaporated salt for most of its end uses.

b. Capacity Utilization

Capacity data for U.S. evaporated salt manufacturing facilities are not available. It is reasonable to assume, however, that plant capacities and demand are in reasonable balance. We base this assumption on the predictable nature of year-to-year demand growth and the fact that the number of evaporated salt producers has not changed. That is, with no new market entrants to upset the supply position of existing competitors and with relatively few year-to-year upsets in the growth pattern, we assume that there has been a disciplined expansion of plant capacity in reasonable concert with market demand.

d. Foreign Competition

Although Bureau of Mines data for salt imports are not segregated by type of salt, the identity of the importing country--and particularly the major importing countries--indicates that only nominal quantities of evaporated salt comes from foreign sources. The major importer of salt to the U.S. is Mexico, supplying almost exclusively solar salt. The next largest importer is Canada, almost all of whose salt exports to the U.S. are in the form of rock salt. The third largest importing country is the Bahamas which supplies solar salt exclusively. The unit value of total imported salt in 1972 was $3.46 per ton, another indication that imports are comprised of the lower valued salt types, i.e., rock salt and solar salt.

e. Abatement Cost Differences

There is no indication in the Development Document that there would be abatement cost differences between the various evaporated salt producers.

f. Price Elasticity of Demand

As indicated by the absence of substitute products and the small percentage represented by evaporated salt of the total manufacturing cost in its applications, demand for evaporated salt is relatively insensitive to price.

g. Basis for Competition

Although price is an important factor in marketing evaporated salt, there is opportunity for product differentiation through quality control, particle size control, and the addition of additives to impart desirable physical and nutritive characteristics for specific use industries. In addition, there is an opportunity and need to provide both technical and marketing service. The opportunity for product differentiation and to provide service to the user also makes nominal price increases possible.

h. Market Share Distribution

Although individual company capacity data are not available (from which market share information could be inferred), it is probable that the three major salt producers—International, Morton, and Diamond Crystal--are also major evaporated salt suppliers. This would indicate a relatively concentrated market share distribution pattern.

3. Plant Shutdown Impact

Based on our conclusion that competitive conditions in the evaporated salt industry will allow producers to pass on the added costs of water treatment through price increases, no plant shutdowns would result from new water quality standards. The relatively high costs of water treatment in comparison with estimated profits (after tax costs equivalent to 13.7% of after tax profits for both B.P.T. and B.A.T.) and fixed investment (an investment in water treatment facilities equivalent to nearly 34% of existing plant investment for both B.P.T. and B.A.T.) suggests that producers would be motivated to recover the investment through price increases.

D. SODIUM SILICATE

1. Summary

The cost of water effluent treatment indicated by the Development Document is small enough that, in an expected environment of relatively high capacity utilization, price increases may be effected to compensate for such increased cost. No plant shutdowns can be anticipated for sodium silicate plants to which the Development Document is applicable.

2. Price Impact

As indicated in the impact analysis matrix the price increase constraints relative to sodium silicate water effluent treatment costs are limited to the following.

a. Capacity Utilization

While 1972 capacity utilization, at approximately 70% of installed capacity, is sufficiently low to contribute to a highly competitive environment, an environment in which price increases necessary to offset water effluent treatment costs might be difficult to achieve, there are indications that a major increase in capacity utilization will be effected over the next two years. After five years of static production volume, U.S. sodium silicate production increased 6% in 1972. And for the first seven months of 1973, production is 13% higher than for the same period of 1972. Thus capacity utilization in 1973 is likely to be 80% and less constraining relative to future price increases.

b. Captive Usage

Sodium silicate is used captively in the production of fluid bed cracking catalysts, rubber reinforcing pigments, detergents, and for further processing to sodium metasilicate. However, many of the captive users also are merchant buyers, frequently on an "over-the-fence" long-term contractual basis. Such contracts tend to influence the marketing environment in much the same way as captive usage. Thus the low captive usage factor is augmented by the special contractual arrangements and is not a substantial constraint in the case of sodium silicate.

c. Demand Growth

Sodium silicate production is recorded by U.S. Department of Commerce:

Year	Production (M Tons)
1967	613
1968	633
1969	657
1970	628
1971	628
1972	663
1973 (7 mo.)	416

As indicated under Capacity Utilization, demand was relatively static for the period 1967-72 and then increased sharply in 1972-73 because of household detergent consumption. The sharp rise in detergent consumption was initially motivated by local legislative restrictions (city, county, state) on phosphate content. The household detergent manufacturers increased silicate content to compensate for phosphate reduction. In the face of an adverse marketing environment, phosphate manufacturers understandably made no plans to expand phosphate capacity. A shortage of phosphates then developed and the high energy requirements of phosphate furnaces probably precludes new furnace capacity in the short term and the long term. As a result the reduction of phosphate content in household detergents and expanded use of solicates is now directly attributable to both the legislative restrictions and the phosphate shortage. In other words, average phosphate content is lower than required to meet legislative restrictions because of phosphate unavailability.

The household detergent reformulation process, and attendant rise in silicate consumption, is not expected to carry beyond 1975, after which the growth in silicate demand should be no more than 2-3% per year. Thus, we have characterized demand growth in the impact analysis matrix as low.

d. Basis for Competition

The primary basis for competition in marketing silicates is price. This does not mean, however, that price competition results in frequent changes of supplier pattern or price erosion. The marketing strategies of major producers depend to a significant degree upon market proximity to large consumers, proximity which frequently includes "over-the fence" transfer, and supply contracts. This tends to provide price stability and an opportunity to negotiate price increases necessary to compensate for increased manufacturing costs.

The above mentioned constraints are unlikely to be significant because the water effluent treatment costs provided by the EPA Development Document are no more than 1% of selling price.

3. Plant Shutdown Impact

In developing the environment for the plant shutdown decision in the impact analysis matrix, the conditions which might lead to a sodium silicate plant shutdown because of the cost of water effluent treatment are described below.

a. Ratio of After Tax Treatment Cost to After Tax Net Income

Lacking current experience detail for after tax net income attributable to sodium silicate production and marketing, we assumed that 5% of selling price was reasonable for this class of inorganic chemical. More thorough economic analysis was not possible under the scope of our assignment. Based on the 1971 Department of Commerce unit sales value, the 5% after tax net income is $4.30 per ton.

The EPA Development Document indicates the cost differential of achieving acceptable effluent treatment via exemplary plant practice as $.40 more than base level practice. The differential over base level practice necessary to achieve best practicable technology or best available technology levels is $.90. Thus the ratios of after tax treatment costs to after tax net income are 10% for E.P.P. and 20% for B.P.T. and B.A.T. Such an impact on profitability, if not recoverable through price increase, could contribute to a decision for plant shutdown.

b. Chemical Complex

Isolated plants are more likely to be shut down because of an inability to take advantage of common effluent treatment facilities. In general the locations of the sodium silicate plants are more influenced by the need for proximity to specific customers than by the advantages of including them in large chemical complexes.

c. Ownership

Because most of the sodium silicate production is owned by large multi-product chemical companies, plant shutdown decisions can be made on the basis of maximum return on investment with a multiplicity of choices. The shutdown of a single plant becomes less critical to the total operations of the corporation and is more readily made than would be the case if a dramatic reduction in total sales were attributed thereto.

E. SODIUM METAL

1. Summary

We expect little economic impact from the imposition of effluent controls to achieve E.P.P., B.P.T., or B.A.T. levels in the production of sodium metal. Sodium metal, produced by the electrolysis of molten sodium chloride, has by far its major application in the production of alkyl leads (tetraethyl and tetramethyl lead) for use in gasoline. The alkyl lead producers have integrated back to sodium metal and account for the great bulk of its production. The costs of effluent control specified by the Development Document, although a significant proportion of the probable profitability of producing sodium metal, are, we believe, a very much smaller proportion of the profitability associated with the entire operation of producing alkyl leads, including the manufacture of metallic sodium. If demand were to be sustained for alkyl leads, the relatively minor cost of effluent control for sodium manufacturing portion of the total process could either be absorbed by the manufacturers or, more likely, passed through to the purchasers of alkyl leads.

The total demand for alkyl leads will very probably decline significantly within the next three to four years. This will occur chiefly because of the imposition of automobile emission control standards. This will reduce the demand for sodium metal and could quite possibly result in the shutdown of some sodium metal producing plants. It would not be reasonable, however, to attribute the plant shutdown to required investment and/or additional cost caused by meeting effluent control standards for metallic sodium. The plants would very likely close in any event with the substantial reduction in demand foreseen.

2. Price Impact

Price increase constraints are not particularly meaningful applied to sodium metal because of the integrated nature of production. Producers of sodium metal account for over three-quarters of its total use in the United States. Most of the "price" therefore is a transfer price within a corporate enterprise. This transfer price could and most likely would be adjusted to take into account the higher manufacturing cost caused by imposition of effluent control standards on the manufacture of sodium metal.

a. Substitute Products

Sodium metal is primarily used in the production of tetralkyl leads (tetraethyl and tetramethyl) which are used as gasoline additives for the prevention of knocking. This end use represented 83% of sales. Tetralkyl lead production depends on sodium. These products have been put in gasoline for decades, and there is no substitute which is as satisfactory for improving octane rating per unit of cost. Nevertheless, certain aromatics may be used in the future because of emissions control standards affecting the use of leads.

Other uses for sodium include reduction of metals, especially titanium (6%), and manufacturing sodium peroxide (2%). Sodium metal receives severe competition from magnesium for use in metal reduction. Demand for sodium peroxide in pulp bleaching has decreased dramatically in recent years, losing markets to other chemical products such as hydrogen peroxide. Thus, for its major use sodium has little substitute product competition, but there is significant substitute product competition for minor uses of sodium.

b. Capacity Utilization

During 1969-1972 nationwide sodium metal manufacturing capacity was 189,000 short tons:

	Tons/Yr.
DuPont, Memphis, Tennessee	35,000
DuPont, Niagara Falls, New York	42,000
Ethyl, Baton Rouge, Louisiana	45,000
Ethyl, Houston, Texas	30,000
Reactive Metals, Inc., Ashtabula, Ohio	37,000
	189,000

For those four years, production and capacity utilization were as follows (in short tons):

	Production	Capacity Utilization
1969	164,700	87%
1970	171,200	91%
1971	153,100	81%
1972	159,900	85%

c. Captive Usage

Sodium is an overwhelmingly "captive" product for tetralkyl lead and other uses. Production is in the hands of three companies—DuPont, Ethyl, and Reactive Metals. DuPont and Ethyl have 83% of the nation's tetralkyl lead manufacturing capacity. Reactive Metals has been the predominant user of sodium for titanium reduction. The highly captive market indicates that decisions regarding sodium metal production will be made in direct consequence of the manufacturers' experience with the sale of end products, primarily tetralkyl leads.

d. Demand Growth

Automobile emission controls will severely decrease the total amount of lead used in gasoline. Likewise, a general decline in aerospace, commercial, and military aircraft and missile spending is causing a dramatic drop in the demand for titanium. Demand for sodium metal may decrease by almost one-third by 1976 or 1977.

e. Price Elasticity of Demand

Because the cost of pollution abatement for producing sodium metal is only a very small fraction of the market price for tetralkyl lead, increased abatement costs will not cause the integrated tetralkyl lead manufacturers to cut back sodium production or close plants. However, decreased market demand for the lead may result in cutbacks and may make it difficult to pass sodium abatement costs on to the purchasers of the lead.

f. Basis for Competition

Most sodium production is captive. Other sales, however, are made primarily on the basis of price. The list price during 1970-1972 has been 18-3/4¢/lb., tanks, works.

g. Market Share Distribution

Sodium production and tetralkyl lead production are concentrated among only a few large companies, all of which have sizable production and comparably sized plants. This condition is favorable for passing on cost increases to consumers.

3. Plant Shutdown Impact

The after-tax pollution abatement costs to reach B.P.T. and B.A.T. levels are provided by the Development Document at approximately $5.00 per ton of sodium produced. We estimate sodium manufacturing costs at $200 per ton including a $60 per ton credit for chlorine produced as a by-product from the electrolysis of sodium chloride. The list price for sodium metal is $375 per ton but we estimate the average price of product sold or transferred is $220 per ton. Effluent control costs to achieve B.P.T. and B.A.T. levels would therefore account for approximately 25% of total profitability. The achievement of E.P.P. levels would require costs of approximately 10% of estimated profitability.

The abatement costs are less significant when one compares them to the list price of tetraethyl lead, the largest selling type of tetralkyl lead. The tetraethyl lead list price is $750 per ton. Only .325 pounds of sodium metal is used to make one pound of tetraethyl lead. The sodium after-tax abatement cost of about $1.00 per ton of tetraethyl lead is quite small compared to the lead's price and probable profitability.

a. Cash Flow

The magnitude of the abatement costs are too small to seriously affect cash flow even if adverse tetralkyl lead market conditions make it difficult to pass the abatement costs on to the consumer.

b. Ratio of Investment in Treatment Facilities to Net Fixed Investment

A 25,000 tons capacity sodium plant requires a fixed investment of approximately $15 million or about $600 per ton of capacity. For that sized plant the investment for pollution abatement at B.P.T. and B.A.T. levels is about $700,000. This ratio of abatement investment (5%) is, therefore, probably not initially restrictive.

c. Integration

Since the manufacturing of sodium metal is overwhelmingly controlled captively by the manufacturers of tetralkyl leads, they would be reluctant to close sodium plants unless they were cutting back on alkyl lead production for other reasons.

d. Emotional Commitment

DuPont, because of its diversity, is probably not deeply committed to sodium metal or tetralkyl lead production. However, for Ethyl Corp. tetralkyl leads are an important part of their business in the United States and abroad, so they would probably have significantly greater interest in continued production.

F. SODIUM SULFITE

1. Summary

The EPA Development Document provides water effluent treatment costs which are unlikely to have any significant economic impact on the small volume of merchant sodium sulfite produced by the process considered in that Development Document. For the uses to which we believe such special grades of sodium sulfate are marketed, the additional cost of water effluent treatment can be either absorbed or compensated for by appropriate price increases.

Our analysis of economic impact is predicated on the structure of water effluent treatment costs described in the Development Document. Due to different approaches to reach different levels and the consequent recovery of different by-product chemicals, costs per ton of product produced decrease dramatically between exemplary plant levels and best available treatment levels. Effluent control costs to reach exemplary plant practice levels are specified at approximately $3.00 a ton in producing sodium sulfite through the reaction of sulfur dioxide with soda ash. To achieve B.P.T. levels requires approximately 10¢ per ton less, and to reach B.A.T. levels provides a net income of approximately $1.55 per ton due to the recovery of sodium sulfite. The Development Document does not specify why, given this possibility, the industry does not currently utilize the recovery system proposed.

The economic impact analysis is difficult due to the fact that the great bulk of merchant sodium sulfite produced and sold is by-product from the production of phenol and resorcinol. A relatively small proportion, probably less than 20%, is high purity material manufactured from soda ash for photographic use and sold at what we believe to be a substantially higher price.

2. Price Impact

As indicated in the impact analysis matrix, the price increase constraints relative to sodium sulfite water treatment costs are the following.

a. Ratio of Before Tax Treatment Cost to Selling Price

The impact analysis matrix shows values ranging from 6% for E.P.P. and B.P.T. to minus 3% for B.A.T. effluent control practices. These treatment costs consider only the process for the manufacture of sodium sulfite from sulfur dioxide and soda ash. The values given are based on the average prices for sodium sulfite obtained from the Census Bureau data for 1971. We believe the relatively small proportion of the sodium sulfite produced by this process, however, sells at significantly higher prices than the average price. Photographic grade sodium sulfite sells at a price of around $200 per ton. On the assumption that sodium sulfite manufactured by the process described goes principally for photographic applications, the ratio of before tax treatment cost to selling price for this particular product is approximately one-quarter of the ratios shown in the impact analysis matrix.

b. Substitute Products

Three fourths or more of the sodium sulfite produced in the United States is used for the production of neutral sulfite semichemical pulp. The pollution, air pollution and particularly water pollution, aspects of the NSSC process can be significantly relieved by the use of new processes which produce a pulp of similar properties without the use of sodium sulfite whether purchased or produced in situ. Thus the largest market for sodium sulfite, one which consumes a majority of the sodium sulfite produced, can utilize substitute products for sodium sulfite if there were significant price increases based on water effluent treatment. Even more important, however, is the probability that such substitution will be effected regardless of whether there are price increases for sodium sulfite. The paper pulp industry will find it more and more difficult to produce and use captive sodium sulfite because of the restricted availability of soda ash as a raw material and the water effluent problems attendant to the manufacture and use of sodium sulfite in the pulping process.

c. Demand Growth

Demand for sodium sulfite has increased in this past decade at a rate of around 4% per year. If, as is indicated, there is major substitution of sodium sulfite used in the production of NSSC type pulp by new non-sulfur utilizing processes, there will be reduced total consumption of sodium sulfite. Even those pulp mills remaining on the use of neutral sulfite semichemical pulping will tend to have a higher future recovery of sulfur and sodium values from pulp liquor due to more stringent effluent controls on the pulp and paper industry. This will mean, therefore, less sodium and sulfur values required for make-up per ton of pulp produced.

d. Abatement Cost Differences

There are quite probably differences in pollution abatement costs between various producing plants. The largest differences very probably would be between those plants producing by-product sodium sulfite from phenol or resorcinol processes and the producers of sodium sulfite by reaction of soda ash and sulfur dioxide. The latter category, the process covered by the Development Document, includes plants with capacities which vary by more than threefold. We would expect there would be significant differences in effluent control costs between the smallest and largest of these plants. The plant specified in the Development Document is for approximately 16,000 tons per year capacity, a relatively large sodium sulfite plant utilizing soda ash and sulfur dioxide.

e. Basis for Competition

For the major market for sodium sulfite, the production of NSSC pulp, price has been the primary consideration in determining source of supply, including the decision to make or buy. In the future, however, the make or buy decision will be complicated by the impact of (1) periods of poor availability of soda ash resulting from shutdowns of Solvay process operations; 92) water pollution problems at NSSC plants leading to installation of direct sodium sulfite recovery; and (3) availability of non-sulfur processes for manufacture of pulp similar in properties to NSSC pulp. The basis of competition for high purity sodium sulfite has been marketing capability as well as price.

3. Plant Shutdown Impact

The following factors relate to the sodium sulfite plant shutdown decision.

a. Ratio of After-Tax Treatment Cost to After Tax Net Income

As previously described, the only treatment cost available from the Development Document is based on soda ash and sulfur dioxide process. We have not developed detailed economics of manufacture by this process as this was not included in the scope of our assignment. We estimate that treatment costs for all three levels of treatment described in the impact matrix would be low relative to profitability. This is based on the assumption that the major part of the product produced is being sold at $200 a ton to the photographic chemical market.

Regardless of profitability, the effluent treatment described by the Development Document to achieve B.A.T. levels would be low relative to profitability as the Development Document specifies that by-product recovery results in the development of a negative cost of about $1.55 per ton of product produced.

The consideration of this ratio is not valid for the great majority of merchant sodium sulfite produced as by-product of phenol and resorcinol production. No costs are available from the Development Document relative to effluent control and a description of profitability of sodium sulfite production via these by-product routes is necessarily arbitrary as the product must be produced, although not necessarily recovered, as a consequence of the production of the major product of concern.

b. Other Environmental Problems

Because sulfur compounds tend to create both air and water pollution problems, and because the production of sodium sulfite is generally associated with phenol production (by-product thereof), resorcinol production (by-product thereof) or pulp production (captive raw material utilization), it is difficult to conceive of such operations having an isolated problem of water pollution tied to the sodium sulfite production alone.

c. Emotional Commitment

Neither the by-product operations nor the NSSC pulp captive production represents emotional commitment. These are essentially viewed as economic necessities.

d. Ownership

Except for the captive NSSC production, sodium sulfite capacity is owned by large multi-product chemical companies with other opportunities for investment besides that represented by sodium sulfite manufacture.

G. CALCIUM CHLORIDE

1. Summary

Because the water effluent treatment costs provided by the Development Document are less than 1% of sales price, we do not foresee significant economic impact for plants where such costs are applicable. High capacity utilitation and concentration of production within two major chemical companies are factors which provide an environment in which the costs incurred may be compensated for by price increases.

2. Price Impact

As indicated in the impact analysis matrix, the price increase constraints relative to calcium chloride water effluent treatment costs are the following:

a. Captive Usage

Captive usage is low in the sense that most of the calcium chloride produced is sold as calcium chloride by the producer and the opportunities for forward integration into products for which calcium chloride is a raw material are limited. Over half of the calcium chloride produced is marketed for highway deicing or rural road dust control, markets served by the calcium chloride producers.

b. Demand Growth

The demand growth over the past five years has been limited to 3-4% per year and this is unlikely to change dramatically in the future. The highway deicing market loss due to local legislation restricting the consumption of salt mixtures (rock salt and calcium chloride) are compensated for by growth in other markets.

Furthermore, the relatively low demand growth is compensated for by the high capacity utilization factor of 90%. High capacity utilization has resulted from plant shutdowns attributed to unfavorable economics and concern about the future markets. The market concerns are ecologically directed and primarily focused on use of calcium chloride and rock salt for highway ice control. The ice-control market has declined from about one-third of the U.S. calcium chloride market to about one-quarter thereof. The plants that were shut down derived by-product calcium chloride from soda ash production by the Solvay process. Reduction of total capacity from these shutdowns in the past few years amounted to about 25% with half of this reduction now regained through expansion of by-product calcium chloride recovery from brine chemical operations for which magnesium hydroxide is the product of primary interest. Capacity utilization is appropriate for the demand growth and therefore low demand growth is not per se a price increase constraint for calcium chloride.

c. Basis for Competition

Historically the price competition for the highway and rural road markets for calcium chloride has been stringent, with freight equalization limiting the marketers' geographic scope. Thus a significant price increase for the product from a specific plant would provide an umbrella for a competitive plant to broaden its geographic scope. The fact that price has been the primary basis for competition is a valid price increase constraint. This is now compensated for by the heavy concentration of market share distribution by two major suppliers holding 80% or more of the market.

d. Number of Producers

While there are about ten U.S. producers of calcium chloride, only two are large volume producers. Five of the smaller volume plants are located in the far western states of California, Washington, and Utah and limited by freight equalization to the western U.S. market. Thus the number of producers is not an effective price increase constraint.

The above constraints are unlikely to be significant because they are largely compensated for by high capacity utilization and concentration of production. Furthermore the water effluent treatment costs provided by the Development Document are only 0.5% of the sales price. However, it is important to emphasize that the effluent treatment costs are not applicable to the production of calcium chloride as a by-product from the manufacture of soda ash by the Solvay process. Furthermore, such calcium chloride treatment costs are associated with soda ash effluent treatment costs. This distinction is important in examining the following factors relevant to a plant shutdown decision.

3. Plant Shutdown Impact

a. Ratio of Treatment Cost to Net Income

As calcium chloride is a by-product of other operations, the definition of net income due to its sale is necessarily arbitrary. In view of the very low treatment cost provided by the Development Document--18 cents before taxes per ton of product--we have assumed this to be a low proportion of the net income assigned to the sale of calcium chloride.

b. Ownership

At least 90% of the calcium chloride capacity is owned by large multi-industry companies, so the plant shutdown decision is unhampered since it is not the major business of the producer. This is evidenced by shutdowns of two calcium chloride operations in the United States in recent years. Thus, if there are price increase constraints, further plant shutdowns might be expected. It is our evaluation, however, that price increase constraints will not prevent necessary increases to cover those water effluent treatment costs presented in the Development Document. Nevertheless, these same water effluent costs do not apply to production of calcium chloride as a by-product of soda ash which is a significant portion of the existing calcium chloride capacity. That capacity which is dependent upon continuance of soda ash production relates primarily to soda ash water effluent treatment costs also presented in this document.

H. SYNTHETIC SODA ASH

1. Summary

As estimated by the Development Document, incremental water treatment costs for synthetic soda ash producers to achieve B.P.T. and B.A.T. levels are 0 and $0.66 per ton, respectively. The B.A.T. cost constitutes 1.9% of the $34.60 per ton selling price in 1972. Even this nominal cost, however, could not be passed on as a price increase by the synthetic soda ash producers if producers of natural soda ash, the primary competitive product to synthetic soda ash, did not correspondingly raise prices. On the other hand, in spite of narrow profit margins for synthetic soda ash producers, the modest magnitude of the after-tax treatment cost which would have to be absorbed and the small amount of plant investment for treatment facilities in comparison to existing fixed investment in production facilities are insufficient to cause plant shutdowns.

2. Price Impact

Competitive conditions in the synthetic soda ash industry are such that severe constraints exist which would make specific price increases to cover large, new costs for water treatment extremely difficult. The primary price increase constraints are the existence of substitute products, declining production of synthetic soda ash, unequal abatement cost differences (with respect to natural soda ash), high price elasticity of demand, and an undifferentiated product wherein price is the only basis for competition.

These constraints against price increase outweigh those factors in the industry which, in the absence of constraints, might make it possible to increase prices. These include a relatively high operating rate at the present time (approximately 95% of capacity in 1972), captive usage representing very nearly 25% of production, the almost complete absence of foreign competition, concentrated market share distribution, and the relatively few (five) producers.

No price increases would be necessary for B.P.T. since the guidelines recommendation is for no change in treatment from current industry practice. That is, the incremental costs for B.P.T. will be zero. (In fact, the Development Document indicated that the E.P.P. resulted in a profit of $1.17 per ton of soda ash produced. The profit resulted from converting 20% of the effluent to saleable calcium chloride.) The revised cost for B.A.T. was estimated at $0.66 per ton, equivalent to 1.90% of the 1972 selling price of $34.60 per ton. Even this nominal charge could not be passed on as price increases by the Solvay soda ash producers if at the time the standard comes into effect there are ample supplies of natural soda ash and caustic soda.

a. Substitute Products

Synthetic soda ash competes directly with natural soda ash as well as caustic soda and, to a lesser extent, with other alkaline materials such as lime and salt cake. The major competition to synthetic soda ash comes from natural soda ash. Natural soda ash is produced primarily in Green River, Wyoming, and to a lesser degree, from naturally occurring salt lake brines in California. Preliminary Commerce Department data indicate that in 1973, production of natural soda ash (estimated at approximately 4 million tons) will surpass production of synthetic soda ash (estimated at 3.6 million tons) for the first time. As recently as 1960, synthetic soda ash represented 85% of total U.S. production of soda ash. There is no significant quality or performance difference between natural and synthetic ash. The loss of market to natural soda ash has been due to significantly lower costs of manufacture for the natural product.

In addition to natural soda ash, synthetic soda ash also competes with caustic soda (which can be substituted in most of the soda ash applications). The substitution of caustic soda for soda ash has occurred at varying rates for the past 15 years or so. For example, soda ash has lost all of the alumina, a major part of the paper, and some phosphate and silicate markets to caustic soda. The selection of soda ash or caustic soda is almost entirely a matter of economics, viz. the delivered price of the two materials on an Na_2O equivalent basis. At the present time both soda ash and caustic soda are in tight supply so that the erosion of soda ash markets by caustic soda has been temporarily arrested.

To a lesser extent soda ash competes with lime and salt cake (sodium sulfate), both lower cost materials than soda ash but with less desirable properties for most of the soda ash applications.

b. Demand Growth

Although overall demand for U.S. soda ash (domestic market plus exports) has grown at an average annual compound rate of about 3% in the last ten years, the output of synthetic soda ash has actually declined. For example, in the mid-1960's synthetic soda ash production was approximately 5 million tons versus 4.3 million tons in 1972. As mentioned, 1973 production will apparently total 3.6 million tons. All of the growth in the total soda ash market has been supplied by natural soda ash (which has also made up the shortfall in soda ash supply resulting from the decline in synthetic soda ash production).

c. Abatement Cost Differences

There is no information in the Development Document which would infer that there are abatement cost differences among the synthetic soda ash producers themselves. However, because the producers of natural soda ash are not faced with comparable water treatment costs, and because synthetic soda ash is directly competitive with natural soda ash, a condition of unequal abatement costs exists which would make it difficult for the synthetic soda ash producer to increase prices if producers of natural soda ash (or caustic soda) did not want to raise prices.

d. Price Elasticity of Demand

Because synthetic soda ash and natural soda ash are completely substitutable one for the other, the price of either one could not be raised to a premium versus the other without a shift in market demand to the lower cost form. A similar situation exists with respect to caustic soda, i.e., if synthetic soda ash prices were increased such that caustic soda became less costly on an ash equivalent delivered basis, there would be a shift of market demand away from synthetic soda ash as sodium alkali consumers used increasing amounts of caustic soda. Because the demand for synthetic soda ash (in competition with natural soda ash or caustic soda) is very sensitive to its price, it would be difficult for the synthetic soda ash producers to raise prices to cover increased costs of water treatment.

e. Basis for Competition

Price is the basis for competition among soda ash producers, representing another strong constraint against higher prices for one of the competing forms of sodium alkali.

3. Plant Shutdown Impact

The synthetic soda ash industry has been characterized in recent years by long periods of marginal profitability interspersed with shorter periods of improved profitability (as in late 1973) when competitive conditions in the industry allowed producers to raise prices in concert with higher natural soda ash and caustic soda prices. The long-term outlook is for minimal and diminishing profit margins for synthetic soda ash producers. In spite of these conditions, the B.A.T. costs of $0.33 per ton (after taxes) are not sufficient by themselves to cause plant shutdowns. (As indicated B.P.T. costs will be zero for the industry.)

a. Ratio Treatment Costs to Net Income

Average after-tax profits for synthetic soda ash producers in 1972 are estimated at $0.75 per ton. In comparison, the B.A.T. after-tax cost of $0.33 per ton would represent very nearly 44% of profits.

b. Cash Flow

In 1972 cash flow for the typical synthetic soda ash plant was $1.75 per ton, made up of the aforementioned $0.75 per ton of after-tax profits plus $1.00 per ton of depreciation. Even after the B.A.T. costs of $0.33 per ton, therefore, cash flow would remain positive.

c. Treatment Facilities Investment

The typical soda ash plant in 1972 had a fixed investment of $8.75 million. The incremental investment for B.A.T. of $1.20 million therefore represents 13.7% of existing plant investment. The investment required for B.A.T. is not a significant sum for the major chemical companies comprising the list of synthetic soda ash producers, either in absolute terms or in comparison with existing fixed plant investment.

d. Integration

The soda ash industry uses some of its output (approximately 25%) captively for production of sodium phosphates, sodium silicates, sodium bicarbonate, sodium chromate, glass (to a very minor extent) and alkaline cleaners. Some of the producers of synthetic soda ash are integrated backward to a minor extent, primarily to lime or limestone. In any event, the degree of vertical integration for any single producer is not sufficient justification for continued plant operation if the economics are unsatisfactory.

I. POTASSIUM SULFATE

1. Summary

The largest quantity of potassium sulfate produced in the U.S. derives from the separation of natural brines. The second most significant process is the manufacture of potassium sulfate from langbeinite through the reaction of this ore with potassium chloride to produce potassium sulfate with magnesium chloride as by-product. Langbeinite processing accounts for approximately 40% of potassium sulfate capacity in the United States. Small amounts are derived from the Hargreaves Process and Mannheim Process in which potassium chloride is treated with sulfur dioxide and sulfuric acid respectively.

The guideline contractor provided treatment costs for the langbeinite process only. On the basis of these given costs, our calculations of profitability, and our estimates of the producers capability of raising prices, we do not expect any significant economic impact on the producers of potassium sulfate by the langbeinite process in meeting the standards established by the Development Document for exemplary plant, best practicable technology or best available technology treatment levels. Producers will raise prices and/or absorb costs without shutting down their facilities.

The Development Document specifies a total annual cost of $395,000 for effluent treatment for a potassium sulfate plant of 500 tons per day capacity. Total annual cost including energy and power costs are $166,000. The Development Document was prepared significantly in advance of the energy shortage and rising energy prices manifest late in 1973. Therefore, we believe that it does not accurately reflect the future costs of effluent treatment. Obviously, the document would also not reflect the capability of the langbeinite plant operators to obtain the necessary energy for effluent treatment.

2. Price Impact

As shown in our impact analysis matrix, there are a number of factors mitigating against price increases by the industry. In spite of these, which are explained in detail below, we believe that the industry will be able to pass on at least a portion of the additional pollution abatement costs incurred for effluent treatment. This belief is based on our expectation that capacity utilization is actually significantly higher than shown by examination of nominal capacity and that the two producers of potassium sulfate from langbeinite, together with the operators of the Great Salt Lake capacity, constitute a sufficiently concentrated production so as to be able to act in their own self interest and pass along additional costs incurred for pollution control.

This pricing flexibility is based on the assumption that (a) there will not be major new U.S. sources of potassium sulfate, and (b) export demand which constitutes a significant proportion of the total will not appreciably soften in future years.

a. Substitute Products

Potassium sulfate, potassium chloride, potassium magnesium sulfate, and potassium nitrate are utilized to provide potassium content for fertilizer application. Demand for potassium chloride, the lowest cost form of potassium, is far higher than for the other potassium salts. Potassium nitrate is very little used and potassium sulfate and potassium magnesium sulfate find application where farmers do not want the chloride ion provided with the use of potassium chloride. Potassium magnesium sulfate, obtained from refined langbeinites has a significantly lower potassium content than potassium sulfate but also has the additional virtue of contributing magnesium to those soils and for those crops where this is desirable.

There is some degree of flexibility of product substitution in the sense that if potassium sulfate prices change dramatically relative to the other sources of potassium, then at least some portion of the consumers of potassium sulfate would probably convert to other forms. We consider it quite unlikely, however, that the relative prices of the materials will change dramatically so as to significantly distort existing patterns of consumption.

b. Capacity Utilization

The U.S. Department of Commerce current industrial reports provide potassium sulfate shipments and production. On 100% potassium sulfate basis, 1971 production was 450,000 tons and 1972 production 402,000 tons. Nominal capacity was as follows:

POTASSIUM SULFATE NOMINAL CAPACITIES
(Thousands of Tons/Year)

		100% K_2SO_4
American Potash & Chemical (Kerr McGee)	Trona, California	65
Duval Corp. (Pennzoil United)	Carlsbad, N. Mexico*	65
IMC	Carlsbad, N. Mexico*	65
Potash Corp. of America (Ideal Basic Industries)	Dumas, Texas**	22
	Fort Worth, Texas***	22
Southwest Potash (AMAX)	Vicksburg, Mississippi	
Others (by-product)	Colorado, Texas, Ohio	20
Great Salt Lake Minerals & Chemicals (Gulf Resources & Chemical Corp--51% and Salzdefurth A.G.--49%)	Great Salt Lake, Utah	185
		527

*From langbeinite.

**Hargreaves process.

***Mannheim process.

On the basis of the capacity shown, production during 1972 was at 76% of the total available capacity. Capacity in fact is highly variable. Both Duval and IMC have probably switched some portion of their available capacity to the manufacture of potassium magnesium sulfate. In addition, Great Salt Lake Minerals & Chemicals has a varying capacity depending upon operating and weather conditions. This company's production of potassium sulfate comes from separation of the salt from brines concentrated in ponds by solar evaporation.

At the present time, there does not seem to be significant surplus capacity overhanging the market. Prices of the product are relatively firm and the market is not behaving as though competitive producers were attempting to utilize over-capacity by bidding for available business.

Two additional potential producers are Occidental Petroleum which is considering production from brines at Searles Lake and a venture by National Lead which has been attempting to develop a brine separation facility at the Great Salt Lake in Utah. The National Lead venture initially planned production of 100,000 tons per year of potassium sulfate. If the capacity for potassium sulfate extraction should be substantially increased by one or both of these producers entering the business, capacity utilization would decline significantly and inhibit opportunity for future price increases.

c. Captive Usage

All of the producers listed above distribute potassium sulfate through fertilizer distributors. IMC may also undertake direct sale to farmers. We do not believe, however, that this is a significant restraint in terms of the pricing capability of the producers.

d. Demand Growth

Shipments of potassium sulfate by U.S. producers over the past five years were as follows:

1968	321,000 tons
1969	263,000
1970	86,000
1971	483,000
1972	388,000

Over this period of time, domestic demand has apparently declined while exports have significantly increased. In the 1967-1968 fertilizer season, exports totaled 104,000 tons on a 100% K_2SO_4 basis, while imports were 61,000 tons, resulting in a net export balance of 43,000 tons. 1972 exports totaled 208,000 tons, excluding Canada, and imports totaled 59,000 tons. Thus while U.S. shipments of potassium sulfate increased between 1968 and 1972 by about 76,000 tons, this was more than accounted for by the increase in net exports over the period of time.

Industry trade estimates suggest an increasing export market at a growth rate of better than 5% per year for the next several years. Domestic demand is expected to demonstrate little or no growth.

e. Abatement Cost Differences

There are both manufacturing cost differences and abatement cost differences among the various producers. The Hargreaves and Mannheim processes are significantly higher cost than the langbeinite process, and, we presume, they have a higher cost than the separation of brines. In the latter case, manufacturing costs will necessarily be somewhat arbitrarily defined because of the variety of co-products from any particular brine.

Abatement costs are provided by the Development Document only for a plant operating on the langbeinite process of 500 tons per day. We assume a smaller plant such as operated by Duval Corporation would have a significantly higher unit cost for pollution abatement. The separation of brine, would, we assume, have no pollution abatement costs associated with the activity, as the process is essentially the extraction of soluble salts from a natural brine.

f. Price

Producers compete on prices more than any other basis and this does impose some restraint on increasing prices. In this case, however, we believe that this effect is outweighed by other conditions involving relatively high fertilizer demand compared to active capacity and that the basis of competition will not be sufficient to restrain the recovery of additional costs through price increases.

3. Plant Shutdown Impact

The Development Document specifies only one type of treatment for effluent control to meet all technology control levels. This provides for an increase from simply pond settling of muds to evaporation and recovery of liquor chemicals and water. By our estimates, the cost of evaporation even at energy values previously assumed, constitutes approximately 16% of profits. These estimates are based on a price of \$45.90 per ton of K_2SO_4 and a manufacturing cost of \$35.00 per ton to yield a profit before taxes of around \$15.00 per ton. The increase in abatement cost suggested by the Development Document totaled \$2.37 per ton assuming 320 operating days per year. Thus while the abatement costs are significant, the profitability of the operation would appear high enough to make these tolerable even without compensating price increases.

It seems to us that the real issue facing the producers of potassium sulfate via the langbeinite process is that they will have to make the required investment in the face of additional potential competition from producers of potassium sulfate from natural brines. This additional investment, described in the Development Document, would total $660,000 for a plant producing 500 tons per day of potassium sulfate. By our calculations, a plant this size operating at 80% of capacity and selling at current prices should be able to pay out this investment in less than one year. On the basis of these calculations, we believe the producers of potassium sulfate by the langbeinite process will not close their plants, although marketing conditions permitting, it may be more advantageous for them to shift a greater proportion of their capacity to the sale of refined langbeinite as sulfate of potash magnesium.